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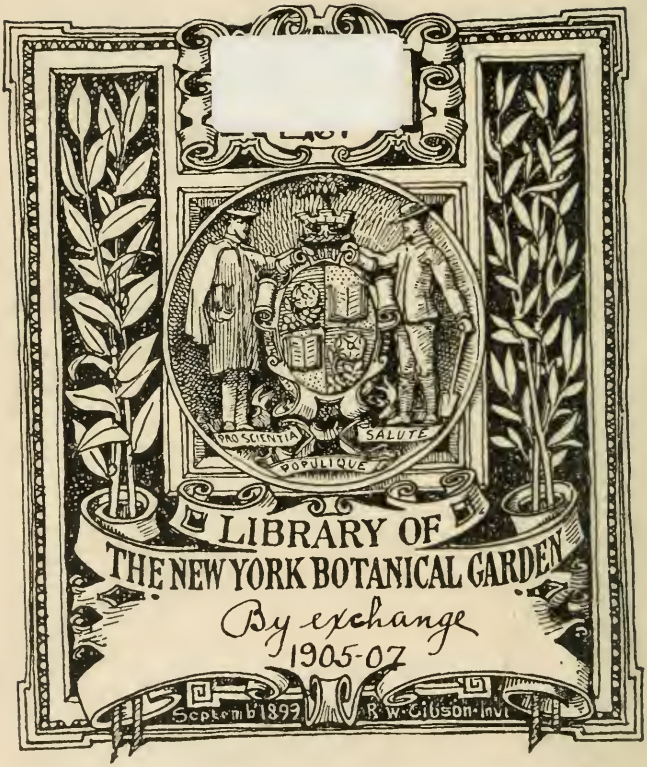

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 162.

A. C. TRUE, Director.

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STUDIES

ON

THE INFLUENCE OF COOKING UPON THE NUTRITIVE VALUE OF MEATS

AT THE

UNIVERSITY OF ILLINOIS,

1903-1904.

BY

H. S. GRINDLEY, Sc. D.,

Professor of General Chemistry, College of Science, University of Illinois,

AND

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

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[Continued on third page of cover.]

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS BULLETIN NO. 162.

A. C. TRUE, Director.

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., December 20, 1905.

Sir: I have the honor to transmit herewith a report of the investigations conducted in 1903-4 by H. S. Grindley, professor of general chemistry at the College of Science of the University of Illinois; and A. D. Emmett, research chemist in the nutrition investigations of the same institution, in accordance with instructions from this Office. As in earlier work, Professor Grindley's object has been to secure accurate information regarding the losses sustained when meat is cooked in different ways, and the effects of cooking upon flavor, palatability, and nutritive value.

In the course of the investigations, material aid has been rendered by Prof. Herbert W. Mumford, of the department of animal husbandry of the Illinois Agricultural Experiment Station, and by Prof. Isabel Bevier, of the department of household science, of the University of Illinois. Acknowledgment should be made of the valuable assistance rendered by Miss E. C. Sprague, and Messrs. F. W. Gill, S. J. McGrath, and J. M. Barnhart.

In the present bulletin, which is considered a progress report, the details of fifty-one experiments are reported, in which studies were made of the nutritive value of different kinds and cuts of meat cooked in various ways.

The investigations reported furnish data of practical as well as scientific interest, and it is recommended that the report be published as Bulletin No. 162 of this Office.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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INFLUENCE OF COOKING UPON THE NUTRITIVE VALUE OF MEATS.

INTRODUCTION.

In the United States there is a greater production of meat than in any other country in the world, our animal products being second only in importance to our cereal products. The reports of the census for 1900 show that the meats and meat products slaughtered and prepared that year by the wholesale packing houses of this country were worth at wholesale prices $779,000,000. It must be remembered that this does not include the value of the meat and meat products which pass directly through the hands of the butchers and other retailers, nor that of animals which the farmers and other consumers slaughter for their own use, so the total value of the meat and meat products would be considerably larger than the figure quoted.

A detailed study of the results of 267 dietary studies which have been made in America shows an average expenditure of 7.2 cents per man per day for meats. The cost of meat forms 37.2 per cent of the total cost of the food, and the meat furnishes 38.6 per cent of the protein, 58.9 per cent of the fat, and 18.5 per cent of the total nutrients of the diet. Furthermore, available statistics show that we also consume more of this food than any other nation, the inhabitants of the United States annually using on an average about 120 pounds of meat per capita.

Since it is evident that meats play such an important rôle in commercial and domestic economy, it seems obvious that there is abundant reason to justify any study, however extended, which will increase our knowledge of the nutritive and economic value of meats and their products.

Investigations made from 1898 to 1903 at the University of Illinois under the auspices of this Office in cooperation with the university, upon the nature and the extent of the losses which meat undergoes during the process of cooking, have already been published.[a] In connection with those investigations a large number of experiments were made which had for their object the determination of the influence of the cooking of meats upon their total digestibility, and upon the ease and rapidity of their digestion, and the results obtained, which have been described in part,[a] it is expected will soon appear in full as a bulletin from this Office.

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[a] U. S. Dept. Agr., Office of Experiment Stations Buls. 102 and 141.

During the year 1903–4 the methods used in these studies have been in a number of ways materially extended in scope and modified in form. The plan of the investigations has also been extended with a view to studying as completely as possible the influence of different methods of cooking upon the nutritive value of meats and the character of the physical and chemical changes which take place in meats when they are cooked by various common methods. It is the object of this bulletin to describe this work and to give in detail some of the results which have so far been obtained.

The work here reported includes (1) thirty-one experiments made to determine the amount of the losses which result in the cooking of meats in hot water at different temperatures and for different lengths of time, a special feature being a detailed study of the nature of the nutritive constituents of the meats before and after cooking; (2) four experiments to estimate the amount and character of the losses which take place when meats are cooked by pan broiling and at the same time to find out the relation existing between the nutritive value of the raw and that of the cooked meats; (3) three experiments to find what losses and changes in nutritive value result when meats are cooked by roasting; (4) six experiments to determine the losses and also the changes in nutritive value which meats undergo when they are cooked by sautéing, frying, gas broiling, and pot roasting; (5) three experiments to show the influence of the different methods of cooking meats upon flavor and palatability, and (6) four experiments to determine the amount and nature of the substances which bones yield when cooked in hot water, as in making soup.

HISTORICAL REVIEW.

A review of chemical literature shows that many studies of the changes brought about in various proteids, fats, and carbohydrates by oxidation by heat or otherwise, and by treatment with water under pressure or other methods of hydration and by the action of different reagents have been undertaken which, properly considered, would throw light on the changes brought about by cooking. But apparently no attempt has as yet been made to collect and digest this widely scattered material. An extended search of the literature of the subject indicates that comparatively few experimental investigations have been undertaken with the direct object of studying the chemical, histological, and other changes which different foods undergo during the process of cooking. Considerable has been said by different writers regarding the effects of cooking upon nutritive value, and more especially upon chemical composition and digestibility, but as a rule the statements are not accompanied by experimental data nor do the generalizations always show evidence of being based upon careful laboratory investigations.

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[a] Univ. Ill., Univ. Studies, vol. 1, No. 5, p. 1.

Many studies have been made with a view to ascertaining the chemical structure of different proteid bodies of animal and vegetable origin, and at the present time many investigators are working along these lines. The majority of the proteids studied, it seems fair to say, are not those occurring in meats used as food, and the statement seems warranted that up to the present time little is definitely known regarding the chemistry of uncooked meats, and still less regarding the complex changes brought about by different methods of cooking. Whatever is known, however, is of great interest and value, not only for itself but for the suggestions it offers for future lines of work.

In 1895 Atwater[a] compiled and studied the results of investigations on the changes brought about when meat and other foods are cooked. The experimental data regarding the effects of cooking on the composition, digestibility, and nutritive value of foods were discussed, as well as data regarding the losses resulting during the cooking of meats, and also regarding the composition and nutritive value of broth.

In König's[b] extended compilation of data relative to the chemistry of foods and food products, investigations are summarized which have to do with the cooking of food. That the amount of such data was limited is shown by the fact that the summary covers only 16 pages.

The results of a number of studies, most of them carried on by American and English investigators, which add to our knowledge of the changes which take place when foods are cooked, have been published but are not included in either of the compilations just cited.

The changes which take place in the carbohydrates when sweet potatoes are baked was studied by W. E. Stone.[c]

Snyder, Frisby, and Bryant[d] have reported determinations of the losses of nutrients resulting in the boiling of potatoes, carrots, and cabbage. Katherine I. Williams[e] has studied in detail the chemical composition of cooked vegetables as served at the table. Voorhees,[f] Isabel Bevier,[g] Snyder,[h] and Woods[i] have published results of investigations showing the losses involved in the process of bread making.

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 21, p. 91.

[b] Chemie der Menschlichen Nahrungs- und Genussmittel. 4. ed., vol. 2, p. 1244.

[c] Ber. Deut. Chem. Gesell., 23 (1890), p. 1406; Agr. Sci., 14 (1890), p. 31.

[d] U. S. Dept. Agr., Office of Experiment Stations Bul. 43.

[e] Jour. Amer. Chem. Soc., 26 (1904), p. 244.

[f] U. S. Dept. Agr., Office of Experiment Stations Buls. 35 and 67.

[g] U. S. Dept. Agr., Office of Experiment Stations Bul. 52.

[h] U. S. Dept. Agr., Office of Experiment Stations Buls. 67, 101, and 126.

[i] U. S. Dept. Agr., Office of Experiment Stations Bul. 85.

The chemistry of cooked meats, and the losses and chemical and physical changes involved in the cooking of meats have also received some attention in recent years. Schwenkenbecher[a] has made a special study of the composition of cooked foods, both animal and vegetable. Katherine I. Williams[b] has analyzed a considerable number of samples of cooked fish of different kinds. Allen[c] reported the results of the analysis of a number of different kinds of cooked meats which were made in his laboratory by A. R. Tankard. Atwater,[d] Grindley,[e] Thudicum,[f] and Grindley and Mojonnier[g] have made and reported investigations which show the nature and extent of the losses which meats undergo during cooking by the methods in common use. Offer and Rosenquist[h] have studied the nature of the nitrogenous principles of poultry, fish, and different kinds of raw, cooked, and preserved meats and in raw and fried veal. Isabel Bevier and Elizabeth C. Sprague[i] have reported investigations regarding the influence of pans of different kinds and shapes, of time of cooking, of temperature, and of different shapes and size of cuts, upon the losses which occur in the roasting of beef. Grindley and Mojonnier[j] have studied the influence of the cooking of meats upon their total digestibility and upon their ease and rapidity of digestion.

M. Rubner,[k] in a recent publication, gives in brief a résumé of researches which have been made in his laboratory upon the chemistry, the cooking, and the nutritive value of meats. The results which were obtained will be referred to in detail in connection with the discussion of several of the topics considered in this bulletin.

The investigations carried on in Illinois in the past have been so largely devoted to the determination of the losses involved in the cooking of meats that they have in the main only indirectly thrown new light upon the character and nature of the physical and chemical changes which meats undergo during cooking, and they have therefore given us only a little additional information regarding the nutritive value of cooked meats. The investigations reported in this bulletin were undertaken for the purposes of studying as thoroughly as possible the changes in nutritive value which meats undergo during the process of cooking.

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[a] Inaug. Diss., Marburg, 1900.

[b] Jour. Chem. Soc. [London], 71 (1897), p. 649.

[c] Commercial Organic Analysis, Philadelphia, 1898, vol. 4, p. 275.

[d] N. Y. State Com. Lunacy, Ann. Rpt., 11 (1900).

[e] U. S. Dept. Agr., Office of Experiment Stations Bul. 102.

[f] The Spirit of Cookery, London, 1895.

[g] U. S. Dept. Agr., Office of Experiment Stations Bul. 141.

[h] Berlin. Klin. Wchnschr., 36 (1899), pp. 937, 968, and 1086.

[i] Illinois Station Circ. 72.

[j] Univ. Ill., Univ. Studies, vol. 1, No. 5, p. 1.

[k] E. von Leyden. Handbuch der Ernährungstherapie. Leipsic, 1903, 2. ed., p. 84.

ANALYTICAL METHODS.

In order to investigate the nature of the physical and chemical changes which occur in the cooking of meats, the ordinary methods for the proximate analysis of foods are not sufficient. Thus, when meat is boiled, the mere determination of the water, protein, fat, and ash in the broth and also in the meat before and after cooking does not give a sufficient amount of information regarding the proximate principles which they contain. Further, there are serious objections to the customary preliminary preparation of air-dried samples, because this procedure produces fundamental changes in the proteid constituents and undoubtedly affects to some extent the nature of the fats and probably also that of the organic extractives. The changes which air drying brings about in the proteids prevent subsequent separation and examination of these substances, since they are for the most part, if not entirely, rendered insoluble by this treatment. Since the investigations here reported seemed to necessitate a study of the water extracts of raw and cooked meats in order to distinguish more completely between their proximate constituents, it seemed desirable to analyze the fresh substance of the meats without first preparing an air-dried sample according to the usual practice.

In former investigations[a] carried out in this laboratory an effort was made to adapt the ordinary methods to the analysis of the fresh substance of both raw and cooked meats without preliminary air drying. At that time the results obtained were not as satisfactory as were desired. Further work has been done, and it is believed that the various modifications here introduced in the details of the ordinary method have produced more accurate results.

In general, the method used follows the outline of procedure recommended by the Association of Official Agricultural Chemists,[b] with such modifications as were described in a former bulletin of this Office,[c] together with further changes of details which have been found necessary when the fresh substance of meats is used instead of the air-dried material. Only these last changes need be described here. Much care was taken in preparing and thoroughly mixing the samples for analysis. In every case the weighings were made by difference, a glass-stoppered weighing bottle being used. For the determination of water the samples were weighed in glass tubes with filter-paper bottoms, such as are ordinarily used in ether extraction of fat by the Johnson method.[d] In cases where the meat was rather fat, filter blocks made of fat-free paper were first put into the tubes, the tubes and their contents were dried at first very slowly in a water oven at a low temperature, and the determination then continued as usual.

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 102.

[b] U. S. Dept. Agr., Division of Chemistry Bul. 46, revised.

[c] U. S. Dept. Agr., Office of Experiment Stations Bul. 141.

[d] Amer. Jour. Sci., 13 (1877), p. 190.

The fat was determined by extracting with anhydrous ether the dried samples remaining after the estimation of water. After twenty-four hours' extraction the samples were removed and intimately ground with ignited sand, then transferred again to the moisture tubes, which were loosely plugged with fat-free cotton to prevent any of the material from being mechanically carried into the flasks, and the extraction continued for twelve hours. The usual Kjeldahl method was used for the determination of the total nitrogen, special care being taken in transferring the weighed meat to the Kjeldahl flask that none of the material should adhere to the neck. In the distillation it was found that pumice stone was preferable to granulated zinc, as experiments made in this laboratory show that zinc reduces some forms of nitrogen compounds which are always present in the ordinary alkali, and thus introduces a slight error. The ash was determined as usual, but much care was taken to heat the muffle very slowly and gradually at first so as to prevent loss by sputtering.

A careful and thorough test of this method for the direct determination of water, fat, nitrogen, and ash in the fresh substance of meats has demonstrated its accuracy, and it may be considered of unquestionable advantage in these investigations or others of similar nature.

PREPARATION AND ANALYSIS OF COLD-WATER EXTRACTS OF MEATS.

As has already been said, in order to learn very much regarding the chemistry of the cooking of meats it is necessary to distinguish much more completely between their proximate principles than is done by the ordinary methods of analysis. It was believed that in the meat investigations here reported, as well as in future work, this could be best accomplished by studying the cold-water extracts of meats. After much preliminary experimenting (which it is not necessary to describe in this connection), a method of preparation and analysis of the cold-water extracts of meats was elaborated and adopted. Since, so far as the authors are aware, no method has been as yet proposed or described for so complete an analysis of meats and other foods, the method used is described here in detail.

The uncooked or cooked meat was cut into small pieces and then passed three times through a small sausage mill or meat cutter. After each grinding, the mill was cleaned and the meat thoroughly mixed. Three portions, of 30 to 33 grams each, were then weighed, the meat being thoroughly mixed each time before any of it was removed. Each lot of 30 to 33 grams was distributed as equally as possible between six small beakers. The samples were moistened with a little distilled water and all lumps broken up with a glass rod. Fifty cubic centimeters of water was then added to each beaker and the contents stirred thoroughly for fifteen minutes. After the insoluble residue had been allowed to settle for three to five minutes, the liquid from each beaker was decanted through filters into 250 cubic centimeter flasks. The insoluble portion was thoroughly drained and then 25 cubic centimeters of water was added. The water and residue were thoroughly stirred for seven to eight minutes, and, after settling, decanted upon the same filter as before. This treatment was continued, 25 cubic centimeters of water being used each time, until the filtrate from each portion of meat measured about 230 cubic centimeters. The material on the filters was allowed to drain completely after each extraction. After the last extraction the entire content of each beaker was thrown upon the filter and, when drained, was washed twice with a small quantity of distilled water. Each flask was rinsed twice with water, after which the filtrates were combined and diluted to 5 liters.

Determination of total solids and ash.—Portions of the filtrate of 100 cubic centimeters each were evaporated to dryness in weighed platinum dishes. The residues were dried in a water oven for one hour or until the weight of each was approximately constant. The dried residues were ignited carefully over a free flame at a very low red heat until colorless or nearly so. The ash was weighed quickly, reheated, and again weighed. This treatment was repeated until the weight was constant.

Determination of total nitrogen.—Portions of 100 cubic centimeters each were used to determine the nitrogen by the usual Kjeldahl method. Dilute standard solutions (about one-fifteenth normal) were used for this part of the work.

Determination of nitrogen precipitated in the form of coagulated proteids in neutral solution.—Portions measuring 200 cubic centimeters were evaporated upon the water bath to a volume of about 40 cubic centimeters. The solution was then exactly neutralized with decinormal sodium hydroxid solution, litmus paper being used as indicator. The neutral solutions were warmed upon the water bath for ten minutes, then filtered at once, and the coagulated residues washed thoroughly with hot water. The nitrogen in the residues was determined, much care being taken to remove all the coagulated proteid from the beakers.

Determination of nitrogen precipitated as albumoses by zinc sulphate.—The filtrates and washings from the above determinations of coagulable proteid were evaporated upon the water bath to a volume of 30 cubic centimeters and allowed to cool. One cubic centimeter of 50 per cent sulphuric acid was added and the solution completely saturated with crystallized zinc sulphate. The solution was heated upon a water bath with constant stirring until perfectly clear, allowed to stand twelve hours and then filtered, after which the precipitate was thoroughly washed with a saturated solution of zinc sulphate, slightly acidified with sulphuric acid. The nitrogen in the precipitate was then determined.

Determination of nitrogen precipitated by tannin and sodium chlorid.—Measured portions of 200 cubic centimeters each of the cold-water extract were transferred to 250 cubic centimeter measuring flasks and 1 gram of pure sodium chlorid and 5 cubic centimeters of a solution containing 12 per cent of tannin were added. The solution was then diluted to 250 cubic centimeters, allowed to stand twelve hours, filtered through a dry filter, and the nitrogen determined in a measured volume (200 cubic centimeters) of the filtrate.

Determination of nitrogen precipitated by phosphotungstic acid from a cold solution.—Measured amounts of 200 cubic centimeters each of the cold-water extract were transferred to 250 cubic centimeter measuring flasks, with 5 cubic centimeters of 50 per cent sulphuric acid and 10 cubic centimeters of phosphotungstic acid solution (prepared as directed by Wiley).[a] The solution was then diluted to 250 cubic centimeters, allowed to stand twelve hours, filtered through a dry filter, and the nitrogen determined in 200 cubic centimeters of the filtrate.

Determination of nitrogen precipitated by phosphotungstic acid from a hot solution.—Measured portions of 200 cubic centimeters each of the cold-water extract were treated with 5 cubic centimeters of 50 per cent sulphuric acid and then heated to rapid boiling. A slight excess (10 to 15 cubic centimeters) of phosphotungstic acid solution was added and after boiling gently for five minutes the hot solution was filtered. The precipitate was washed thoroughly with boiling water and then the nitrogen which it contained was determined.

Determination of nitrogen precipitated by Stutzer's reagent.—Measured amounts of 200 cubic centimeters of the cold-water extract each were placed in 250 cubic centimeter measuring flasks and 3 cubic centimeters of Stutzer's reagent was added. The solution was then diluted to 250 cubic centimeters, thoroughly mixed, allowed to stand twelve hours, filtered through a dry filter, and the nitrogen determined in measured portions (200 cubic centimeters) of the filtrate.

Determination of nitrogen as ammonia.—Portions of 200 cubic centimeters each of the cold-water extract were distilled with magnesium oxid in the form of milk of magnesia and the ammonia thus liberated was determined in the usual way.

Determination of nitrogen compounds precipitated directly by bromin.[b]—Portions of 200 cubic centimeters each of the cold-water extract were transferred to Kjeldahl digestion flasks, acidified with 2 cubic centimeters of normal hydrochloric acid, and then treated with a slight excess of bromin while being vigorously shaken. The mixture was allowed to stand twenty-four hours, then filtered, and the precipitate washed thoroughly with water saturated with bromin. The nitrogen was then determined in the precipitated proteid.

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[a] Principles of Agricultural Analysis, vol. 3, p. 454.

[b] This determination has recently been discontinued, as bromin has been proved to be an unreliable precipitant for proteids.

Determination of nitrogen precipitated by bromin in the filtrate from the zinc sulphate precipitate.[a]—The zinc sulphate filtrate was diluted with an equal volume of water and 2 cubic centimeters of normal hydrochloric acid was added. The precipitation with bromin was continued as in the determination described above.

METHODS OF ANALYZING THE BROTHS.

The methods used in analyzing the broths in the experiments here reported are fundamentally the same as those described in previous bulletins of this Office.[b] Nevertheless, as they differ in some of the details, a brief outline of them is here given. Upon removing the cooked meat from the vessel in which it was boiled, the hot broth was immediately filtered through a sieve with circular openings of 1 millimeter. The residue in the sieve, consisting chiefly of fragments of meat, was added to the cooked meat. The broth was rapidly cooled to about 15° C. and strained through a piece of cheese cloth previously washed with water, alcohol, and ether. By this means most of the suspended coagulated albumin and nearly all of the solidified fat were separated. This coarse residue, after being washed with cold water, was dried and analyzed, first the fat and then the nitrogen being determined. The filtered broth was diluted with water to a definite volume and after thorough mixing six portions of 250 cubic centimeters each were filtered through ash-free filters. In this manner a clear broth was obtained. The solid material collected upon the filters was designated as "fine residues," and the ash, nitrogen, and fat in these residues were determined in duplicate. The total solid matter, ash, proteid nitrogen, nonproteid nitrogen, and extractives in the clear filtered broths were determined by the methods described above for the analysis of the cold-water extracts of meats, and in addition, in order to get if possible a further insight into the nature of the nitrogeneous constituents present in broths and to study and compare methods for determining these bodies, the following determinations were made: Nitrogenous compounds precipitated by bromin directly; nitrogenous constituents precipitated by tannin and sodium chlorid; compounds of nitrogen precipitated by phosphotungstic acid in the cold; nitrogenous substances precipitated by phosphotungstic acid in boiling solutions; nitrogenous bodies precipitated by Stutzer's reagent, and nitrogen as ammonia or its compounds. The methods used in making these determinations in broths were similar to those described above for their determination in the cold-water extracts.

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[a] This determination has recently been discontinued, as bromin has been proved to be an unreliable precipitant for peptones.

[b] U. S. Dept. Agr., Office of Experiment Stations Buls. 102 and 141.

OBJECT AND PLAN OF THE COOKING EXPERIMENTS.

The object of the experiments here reported, expressed briefly and concisely, was to study: (1) the losses resulting from different processes of cooking; (2) the influence of cooking on the composition and nutritive value of meats; (3) the nature of the changes in composition resulting when meat is cooked by different methods; and (4) the nature of the water extracts of raw and cooked meats.

In planning the work it was naturally found that the results of one experiment might help toward the solution of several of these problems, and the question of their classification was thereby rendered complex. For instance, the main purpose of Series VIII was to test the differences between the changes occurring in different cuts of meat all cooked by the same method, and in the first three experiments (Nos. 121–123) three different cuts of beef were boiled in exactly similar ways. But in the fourth experiment (No. 124) the purpose was to study the differences produced by different methods of cooking on the same cut, and a piece of meat like that boiled in experiment No. 123 was pan broiled. Thus experiment No. 123 really belongs to two separate series, but for convenience both are included in one series. The classification finally adopted is based on the kind of meat and the method of cooking rather than upon chronological sequence. If the results of any individual experiment can advantageously be used in connection with another series, reference can be made to it by number, as will be done in later sections of this bulletin.

Although the method of cooking is not the most important feature of all these experiments, it is nevertheless one from which many significant deductions can be drawn. Boiling, pan broiling, roasting, sautéing, frying, gas broiling, and pot roasting were the methods employed. They were essentially the same as those described in a previous bulletin of this Office,[a] any minor variations being given with the individual experiments. In experiments Nos. 119, 124, 142, and 151 the samples were pan broiled; in Nos. 120, 147, and 156 they were roasted; in Nos. 141 and 150, sautéed; in No. 143, fried; in No. 152, gas broiled; and in Nos. 146 and 155, pot roasted. In the remaining experiments (Nos. 107–118, 121–123, 125, 126, 131–140, 144, 145, 153, and 154) the meats were cooked by boiling, and a detailed description of this method is here given, partly to explain the somewhat complicated processes by which the complete results were obtained and partly because of the special importance of the broths so produced.

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. No. 141.

There is considerable variation in the way in which the terms "boiling," "stewing," and "simmering" are used. In the present investigation, as was the case in earlier work, the term "boiling" has been used to cover cooking in hot water at any temperature; however, in every case the temperature of the water during cooking has been recorded, so it will not be difficult, should it at any time be desirable, to decide whether the meat was cooked by stewing, simmering, or true boiling.

The steps which were taken in developing the experimental methods for determining the losses of nutrients and the chemical and nutritive changes which result in the cooking of meats by boiling have been given in full in previous publications from this Office.[a] It is, however, necessary to say in this connection that in cooking meat in hot or in boiling water it was found that there was no appreciable loss of nutritive material by volatilization, but that practically all the nutrients removed from meat by this method of cooking passed into the resulting broth. In reporting the results of these investigations all material separated from the meat during the cooking, whether mechanically or by solution, has therefore been designated "loss" by cooking. The material thus removed, however, is not necessarily an actual loss from the standpoint of household economy if the broth is used as soup or is otherwise consumed as food.

In each cooking experiment one sample of meat was reserved uncooked for direct analysis. The portions cooked were weighed before and after cooking, and the difference in each case was taken as representing the total loss in weight resulting from the process of cooking. The material lost consisted partly of water and partly of nutritive ingredients contained in the broth. The broth was analyzed by the methods given above (see pages 15, 16), the proteid, fat, ash, and organic extractives, both nitrogenous and nonnitrogenous, being determined. The total loss in weight minus the weight of these ingredients in the broth was assumed to represent the quantity of water removed from the meat in cooking. The cooked meat was then analyzed and the amount of each nutrient in it was added to that in the broth and the sum taken as the amount of the nutrients in the raw meat. This was found in every case to correspond so closely to the figures obtained by the direct analysis of the uncooked samples that it seemed fair to include the results of the two methods in one table, as has been done in the report of the experiments. From these amounts and the amounts in the broth the percentage loss of each ingredient was calculated.

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[a] U. S. Dept. Agr., Office of Experiment Stations Buls. 102 and 141.

The calculation and interpretation of the results of the experiments may be illustrated by the following examples: In experiment No. 108 (p. 22) the weight of the meat before cooking was 1,000 grams and the weight of the cooked meat 534.54 grams. The total loss in weight was therefore 465.46 grams, which is equivalent to a loss of 46.55 per cent of the weight of the original meat.

The chemical composition of the edible portion of the meat before and after cooking and also of the resulting broth is shown in Table 3 (p. 23). The composition of the uncooked beef round was found by direct analysis to be: Water 74.04 per cent, proteid 19.63 per cent, nitrogenous extractives 1.37 per cent, nonnitrogenous extractives 1.72 per cent, fat 3.19 per cent, and ash 1.18 per cent. The same table shows that the composition of the cooked beef round from another similar sample analyzed after cooking was: Water 59.01 per cent, proteid 36.27 per cent, nitrogenous extractives 0.33 per cent, nonnitrogenous extractives 0.45 per cent, fat 4.38 per cent, and ash 0.50 per cent. The percentage composition of the complete broth reckoned on the basis of the total weight of uncooked meat from which it was made as shown by this same table is, proteid 0.64 per cent, nitrogenous extractives 1.06 per cent, nonnitrogenous extractives 1.36 per cent, fat 0.61 per cent, and ash 0.76 per cent.

The results of these analyses of the raw and cooked meats and the broth have been calculated to the water-free basis and the values thus obtained are given in the same table (No. 3).

The quantities of the nutrients in the uncooked and cooked meats and the broth, which are soluble in water, are also given in Table 3, section B. Referring to this table, it will be seen that before cooking, the beef round used in this experiment, or a sample so similar as to be comparable, contained the following nutrients which were soluble in cold water: Proteid, 2.77 per cent; nitrogenous extractives, 1.37 per cent; nonnitrogenous extractives, 1.72 per cent; fat, none; ash, 0.98 per cent; making a total of 6.84 per cent. On the other hand, the same beef round, after cooking by boiling in water as already described, contained the following percentages of soluble nutrients: Proteid, 0.38; nitrogenous extractives, 0.33; nonnitrogenous extractives 0.45; fat, none, and ash, 0.29; making a total of only 1.45 per cent of material soluble in cold water.

In like manner the quantity of soluble constituents in the broth as actually determined by analysis is given in the same table. The amounts of the water-soluble constituents which occur in the meats and the broth have been calculated to the water-free basis, and the results are also reported in Table 3. Finally, the nutrients in the raw and cooked meats and in the broth which are insoluble in cold water are given in section C of the table.

In Table 4, giving the final results of cooking experiment No. 108, it will be noticed that the total nutrients in the cooked meat are, water 315.43 grams; proteid, 193.88 grams; nitrogenous extractives, 1.76 grams; nonnitrogenous extractives, 2.41 grams; fat, 23.41 grams, and ash, 2.67 grams. The entire amount of water in the cooked meat was found by multiplying the weight of the cooked meat (534.54 grams) by the percentage of water (59.01) found in the cooked meat, which gave 315.43 grams. By similar calculations the weights of proteid, nitrogenous extractives, nonnitrogenous extractives, fat, and mineral matter (ash) in the entire cooked meat were obtained.

In the next line of Table 4 there is given the weight of nutrients in the broth resulting from the cooking of meat No. 1641. These values, with the exception of the data for water, were obtained directly by the chemical analysis of the original complete broth. In other words, by analysis of the entire broth resulting in this experiment, it was found that it contained 6.42 grams of proteid, 10.63 grams of nitrogenous extractives, 13.59 grams of nonnitrogenous extractives, 6.09 grams of fat, and 7.57 grams of ash. The sum of these five quantities, 44.30 grams, represents the total nutrients in the entire broth. This quantity, subtracted from 465.46 grams, the total loss in weight resulting in cooking, gives 421.16 grams, the amount of water removed from the meat during the cooking.

In the third line of Table 4 are given the weights of the nutrients in the uncooked meat used in experiment No. 108. These data were obtained by adding the weight of each nutrient in the cooked meat to the weight of each nutrient found in the broth. The uncooked meat (No. 1640) weighing 1,000 grams, may therefore be said to contain 736.59 grams of water, 200.30 grams of proteid, 12.39 grams of nitrogenous extractives, 16 grams of nonnitrogenous extractives, 29.50 grams of fat, and 10.24 grams of ash. It should be noted that these figures are obtained by computation from the analyses of cooked meat and broth from sample No. 1641, rather than by direct analysis of sample No. 1640. But by comparing them with the percentages obtained by direct analysis of sample No. 1640, given in Table No. 3, it will be seen that the differences are so slight as to be practically negligible.

The tabulated statement of the several experiments also shows the amount of each nutrient remaining in the cooked meat, and the amount of each nutrient found in the resulting broth, expressed in percentages of the total weight of each nutrient contained in the original meat. Thus in the experiment in question, No. 108, the weight of water (315.43 grams) found in the cooked meat was divided by the total weight of water (736.59 grams) contained in the uncooked meat and then multiplied by 100, which gave the percentage of water (42.82) originally contained in the uncooked meat, which still remained in the cooked meat. In the same way, the percentage of water contained in the broth or removed during the cooking was obtained by dividing the weight of water (421.16 grams) found in the broth by the total weight of water (736.59 grams) contained in the uncooked meat and then multiplying by 100.

Similar calculations serve to show the percentages of proteid, nitrogenous extractives, nonnitrogenous extractives, fat, and ash remaining in the uncooked meat, and the percentages of these same nutrients which enter the broth during the cooking. In this experiment (p. 24) the following percentages of nutrients of the original uncooked meat were found in the cooked product: Water 42.82, proteid 96.79, nitrogenous extractives 14.20, nonnitrogenous extractives 15.06, fat 79.35, and ash 26.07. The broth contained the following percentages of the nutrients of the original uncooked meat: Water 57.18, proteid 3.21, nitrogenous extractives 85.80, nonnitrogenous extractives 84.94, fat 20.65, and ash 73.93.

Finally, the table for each experiment gives the percentage of total amounts of each nutrient in the uncooked meat which is found in the broth. Again, referring to experiment No. 108, the last row of figures in Table 4 gives these data. For example, the weight of water (421.16 grams) in the broth is divided by the weight of the uncooked meat (1,000 grams), and the quotient multiplied by 100 gives the percentage of water (42.12) which is removed by cooking, calculated on the basis of the total weight of uncooked meat. In the same manner, by dividing the weight of proteid (6.42 grams) in the broth by the weight of the uncooked meat (1,000 grams) and multiplying the quotient by 100, the product 0.64 represents the percentage amount of nitrogenous matter in the broth in terms of the weight of the uncooked meat.

COOKING EXPERIMENTS NOS. 107–157.

Each series of experiments is preceded by a short statement giving its purpose and general plan. The individual experiments then follow, and the kind and amount of meat used, the method and time of cooking, and any other necessary facts or observations are in every case recorded in full. Preceding the tabular statement of the details of each experiment, is a paragraph giving the weight of the raw and the cooked meat, and the actual and percentage loss of weight resulting from the cooking.

MEATS COOKED BY BOILING.

Series I.—Experiment No. 107.

In this experiment the meat was cooked in water kept at the boiling point. The lean beef round which was used was freed from all bone and visible gristle and fat, cut into pieces 0.5 to 0.75 inch thick and 0.75 inch to 1.25 inches long and after being thoroughly mixed was divided into two portions; one (sample No. 1639) being cooked and the other (No. 1637) analyzed raw. Investigations made in this laboratory have shown that by such treatment two samples of meat practically alike in chemical composition may with care be obtained from the same cut. The first portion, cut into cubes (sample No. 1639), was placed in 2,000 cubic centimeters of vigorously boiling distilled water. The addition of the meat reduced the temperature of the water to 90° C., but it was raised to the boiling point again in five minutes, and the cooking continued for five hours and fifteen minutes at this temperature. The fibers of the cooked meat had a slightly pink color, and separated very easily, but were tough and not easily cut through. During the cooking a considerable quantity of shreds separated and settled to the bottom of the kettle.

The weight before and after cooking was as follows:

Weight of meat before cooking	grams..	1,000.00
Weight of meat after cooking	do....	541.36
Loss in weight in cooking	do....	458.64
Loss in weight in cooking	per cent..	45.86

Tables 1 and 2 show the results of the experiment.

TABLE 1.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 107.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1637	Beef, round, uncooked	75.53	19.01	1.08	2.22	(a)	1.19	(a)	3.390
1639	Beef, round, cooked	59.68	34.29	.48	1.19	(a)	.79	(a)	5.640
1639	Broth (percent uncooked meat)	....	.51	.89	1.25	0.74	.67	4.06	.367
	ON WATER-FREE BASIS.								
1637	Beef, round, uncooked	....	77.68	4.41	9.07	(a)	4.86	(a)	13.854
1639	Beef, round, cooked	....	85.04	1.19	2.95	(a)	1.96	(a)	13.988
1639	Broth (percent uncooked meat)	....	2.10	3.63	5.11	3.03	2.72	16.59	1.499

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1637	Beef, round, uncooked	....	2.76	1.08	2.22	0	0.98	7.04	0.790
1639	Beef, round, cooked	....	.97	.48	1.19	0	.50	3.14	.309
1639	Broth (percent uncooked meat)	....	.34	.89	1.25	0	.67	3.15	.339
	ON WATER-FREE BASIS.								
1637	Beef, round, uncooked	....	11.27	4.41	9.07	0	4.00	28.75	3.229
1639	Beef, round, cooked	....	2.40	1.19	2.95	0	1.24	7.78	.766
1639	Broth (percent uncooked meat)	....	1.40	3.63	5.11	0	2.72	12.85	1.386

[a] Determination lost.

TABLE 1.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 107*—Continued.

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1637	Beef, round, uncooked	....	16.25	0	0	(a)	0.21	(a)	2.600
1639	Beef, round, cooked	....	33.32	0	0	(a)	.29	(a)	5.331
1639	Broth (percent uncooked meat)	....	.17	0	0	0.74	....	0.91	.028
	ON WATER-FREE BASIS.								
1637	Beef, round, uncooked	....	66.41	0	0	(a)	.86	(a)	10.625
1639	Beef, round, cooked	....	82.64	0	0	(a)	.72	(a)	13.222
1639	Broth (percent uncooked meat)	....	.70	0	0	3.03	....	3.73	.113

[a] Determination lost.

TABLE 2.—*Results of cooking (boiling) experiment No. 107.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1639	In cooked meat	323.08	185.63	2.60	6.44	(a)	4.28
1639	In broth	418.03	5.15	8.88	12.50	7.42	6.66
1637	In uncooked meat	741.11	190.78	11.48	18.94	(a)	10.94
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1639	In cooked meat	43.59	97.30	22.65	34.00	(a)	39.12
1639	In broth	56.41	2.70	77.35	66.00	(a)	60.88
1639	In broth on basis of total weight of uncooked meat	41.80	.52	.89	1.25	0.74	.67

[a] Determination lost.

SERIES II.—EXPERIMENTS NOS. 108, 109.

The special object of these experiments was to study and compare the chemical and nutritive changes taking place when meat is cooked (1) by putting it in boiling water for ten minutes and then cooking it at 85° C. for three hours, and (2) by allowing it to stand in cold water for one hour, gradually increasing the temperature during the following hour until it reached 85° C. and then, finally, allowing it to cook for three hours at this temperature.

COOKING EXPERIMENT NO. 108.

The lean beef round used in experiment 108 was freed from all bone, visible gristle and fat, cut into cubes about 1 inch square, and intimately mixed.

One sample (No. 1640) was analyzed raw, the other (No. 1641), which weighed 1,000 grams, was used for the cooking test. It was placed in 2,000 cubic centimeters of vigorously boiling distilled water for ten minutes, the temperature then allowed to drop to 85° C., and the cooking continued at this temperature for three hours.

The weight before and after cooking was as follows:

Weight of meat before cooking	grams..	1,000.00
Weight of meat after cooking	do....	534.54
Loss in weight in cooking	do....	465.46
Loss in weight in cooking	per cent..	46.55

The details of the experiment are shown in Tables 3 and 4.

TABLE 3.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 108.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1640	Beef, round, uncooked	74.04	19.63	1.37	1.72	3.19	1.18	27.09	3.580
1641	Beef, round, cooked	59.01	36.27	.33	.45	4.38	.50	41.93	5.910
1641	Broth (percent uncooked meat)		.64	1.06	1.36	.61	.76	4.43	.444
	ON WATER-FREE BASIS.								
1640	Beef, round, uncooked		75.62	5.28	6.62	12.29	4.55	104.36	13.791
1641	Beef, round, cooked		88.48	.81	1.10	10.69	1.22	102.30	14.418
1641	Broth (percent uncooked meat)		2.48	4.10	5.24	2.35	2.91	17.08	1.709

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.								
1640	Beef, round, uncooked		2.77	1.37	1.72	0	0.98	6.84	0.883
1641	Beef, round, cooked		.38	.33	.45	0	.29	1.45	.168
1641	Broth (percent uncooked meat)		.22	1.06	1.36	0	.75	3.39	.376
	ON WATER-FREE BASIS.								
1640	Beef, round, uncooked		10.68	5.28	6.62	0	3.77	26.35	3.491
1541	Beef, round, cooked		.93	.81	1.10	0	.71	3.55	.410
1641	Broth (percent uncooked meat)		.84	4.10	5.24	0	2.90	13.08	1.447

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.								
1640	Beef, round, uncooked		16.86	0	0	3.19	0.20	20.25	2.697
1641	Beef, round, cooked		35.89	0	0	4.38	.21	40.48	5.742
1641	Broth (percent uncooked meat)		.42	0	0	.61	.01	1.04	.068
	ON WATER-FREE BASIS.								
1640	Beef, round, uncooked		64.94	0	0	12.29	.78	78.01	10.390
1641	Beef, round, cooked		87.55	0	0	10.69	.51	98.75	14.008
1641	Broth (percent uncooked meat)		1.64	0	0	2.35	.01	4.00	.262

Table 4.—*Results of cooking (boiling) experiment No. 108.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1641	In cooked meat	315.43	193.88	1.76	2.41	23.41	2.67
1641	In broth	421.16	6.42	10.63	13.59	6.09	7.57
1640	In uncooked meat	736.59	200.30	12.39	16.00	29.50	10.24
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1641	In cooked meat	42.82	96.79	14.20	15.06	79.35	26.07
1641	In broth	57.18	3.21	85.80	84.94	20.65	73.93
1641	In broth on basis of total weight of uncooked meat	42.12	.64	1.06	1.36	.61	.76

Cooking Experiment No. 109.

The meat used in this experiment was from the same cut of beef round as that used in the above experiment (No. 108), and it was prepared for cooking in the same way. The method of cooking was, however, entirely different. The 1,000-gram portion, cut into cubes, was placed in 2,000 cubic centimeters of cold water and allowed to stand for one hour. The temperature of the water was then gradually increased, reaching 85° C. in one hour. The meat was then cooked for three hours longer at this temperature.

The weight before and after cooking was as follows:

Weight of meat before cooking	grams	1,000.00
Weight of meat after cooking	do	517.48
Loss in weight in cooking	do	482.52
Loss in weight in cooking	per cent	48.25

The results of the experiment are shown in Tables 5 and 6.

Table 5.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 109.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Protied.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct*	*Per ct.*	*Per ct.*
1640	Beef, round, uncooked	74.04	19.63	1.37	1.72	3.19	1 18	27.09	3.580
1642	Beef, round, cooked	59.91	35.20	.43	.56	3.93	.51	40.63	5.770
1642	Broth (percent uncooked meat)	....	1.56	1.02	1.34	.59	.77	5.28	.576
	ON WATER-FREE BASIS.								
1640	Beef, round, uncooked	....	75.62	5.28	6.62	12.29	4.55	104.36	13.791
1642	Beef, round, cooked	....	87.80	1.07	1.40	9.80	1.27	101.34	14.393
1642	Broth (percent uncooked meat)	....	6.00	3.93	5.16	2.29	2.98	20.36	2.220

Table 5.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 109*—Continued.

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non. nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1640	Beef, round, uncooked		2.77	1.37	1.72	0	0.98	6.84	0.883
1642	Beef, round, cooked		.43	.43	.56	0	.27	1.39	.160
1642	Broth (percent uncooked meat)		.47	1.02	1.34	0	.77	3.30	.355
	ON WATER-FREE BASIS.								
1640	Beef, round, uncooked		10.68	5.28	6.62	0	3.77	26.35	3.402
1642	Beef, round, cooked		.35	1.07	1.40	0	.67	3.49	.399
1642	Broth (percent uncooked meat)		.66	3.93	5.16	0	2.98	12.73	1.367

C. NUTRIENTS INSOLUBLE IN COLD WATER.

	ON FRESH BASIS.								
1640	Beef, round, uncooked		16.86	0	0	3.19	0.20	20.25	2.697
1642	Beef, round, cooked		35.07	0	0	3.93	.24	39.24	5.610
1642	Broth (percent uncooked meat)		1.39	0	0	.59	....	1.98	.221
	ON WATER-FREE BASIS.								
1640	Beef, round, uncooked		64.94	0	0	12.29	.78	78.01	10.389
1642	Beef, round, cooked		87.45	0	0	9.80	.60	97.85	13.994
1642	Broth (percent uncooked meat)		5.34	0	0	2.29	....	7.63	.853

Table 6.—*Results of cooking (boiling) experiment No. 109.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1642	In cooked meat	310.02	182.15	2.23	2.90	20.34	2.64
1642	In broth	429.69	15.57	10.21	13.38	5.94	7.73
1640	In uncooked meat	739.71	197.72	12.44	16.28	26.28	10.37
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1642	In cooked meat	41.91	92.13	17.93	17.81	77.40	25.46
1642	In broth	58.09	7.87	82.07	82.19	22.60	74.54
1642	In broth on basis of total weight of uncooked meat	42.97	1.56	1.02	1.34	.59	.77

Series III.—Experiments Nos. 110–118.

The four experiments in this series were all made with the same cut of meat, the object being to determine the nature of the changes in composition and nutritive value and the losses involved when meat is cooked (1) in boiling water for the entire period; (2) in boiling water for ten minutes and then at 85° C.; (3) by immersing it in cold water and warming gradually, taking one hour to raise the temperature to 85° C. and completing the cooking at this temperature, and (4) by immersing it in cold water and warming gradually, taking one hour to reach a temperature of 65° C., and completing the cooking at 64 to 65° C. The entire cut of fresh lean beef round was freed from all bone, visible gristle, and most of the visible fat, cut into pieces 0.5 to 0.75 inch thick and from 0.75 to 1.25 inches long, and thoroughly mixed. Four samples (Nos. 1643, 1644, 1645, and 1646) were used for the four following cooking experiments and one (No. 1647) was analyzed raw.

COOKING EXPERIMENT No. 110.

The first portion, weighing 1,000 grams, was cut into cubes and cooked by plunging it into 2,000 cubic centimeters of vigorously boiling distilled water. The meat was then cooked for five hours in gently boiling water.

The losses in weight during cooking were as follows:

Weight of meat before cooking ....grams..	1,000.00
Weight of meat after cooking ....do....	547.51
Loss in weight in cooking ....do....	452.49
Loss in weight in cooking ....per cent..	45.25

Tables 7 and 8 give the details of the experiment.

TABLE 7.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 110.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1647	Beef, round, uncooked........	74.18	18.11	1.41	1.95	4.28	1.28	27.03	3.350
1643	Beef, round, cooked...........	60.52	32.68	.44	.57	5.66	.74	40.09	5.370
1643	Broth (percent uncooked meat)	....	.62	.88	1.09	.85	.64	4.08	.379
	ON WATER-FREE BASIS.								
1647	Beef, round, uncooked........	....	70.14	5.46	7.55	16.58	4.96	104.69	12.979
1643	Beef, round, cooked...........	....	82.78	1.12	1.44	14.34	1.87	101.55	13.602
1643	Broth (percent uncooked meat)	....	2.40	3.39	4.23	3.28	2.47	15.77	1.469

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1647	Beef, round, uncooked................		1.82	1.41	1.95	0	0.94	6.12	0.744
1643	Beef, round, cooked....................		.92	.44	.57	0	.44	2.37	.288
1643	Broth (percent uncooked meat)		.41	.88	1.09	0	.64	3.02	.346
	ON WATER-FREE BASIS.								
1647	Beef, round, uncooked................		7.05	5.46	7.55	0	3.64	23.70	2.881
1643	Beef, round, cooked....................		2.33	1.12	1.44	0	1.11	6.00	.729
1643	Broth (percent uncooked meat)		1.57	3.39	4.23	0	2.47	11.66	1.339

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1647	Beef, round, uncooked........	....	16.29	0	0	4.28	0.34	20.91	2.606
1643	Beef, round, cooked...........	....	31.76	0	0	5.66	.30	37.72	5.082
1643	Broth (percent uncooked meat)	....	.21	0	0	.85	....	1.06	.033
	ON WATER-FREE BASIS.								
1647	Beef, round, uncooked........	....	63.09	0	0	16.58	1.32	80.99	10.092
1643	Beef, round, cooked...........	....	80.45	0	0	14.34	.76	95.55	12.873
1643	Broth (percent uncooked meat)	....	.83	0	0	3.28	....	4.11	.130

TABLE 8.—*Results of cooking (boiling) experiment No. 110.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1643	In cooked meat	331.35	178.93	2.41	3.12	30.99	4.05
1643	In broth	411.77	6.18	8.76	10.92	8.48	6.38
1647	In uncooked meat	743.12	185.11	11.17	14.04	39.47	10.43
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1643	In cooked meat	44.59	96.66	21.58	22.22	78.52	38.83
1643	In broth	55.41	3.34	78.42	77.78	21.48	61.17
1643	In broth on basis of total weight of uncooked meat	41.18	.62	.88	1.09	.85	.64

COOKING EXPERIMENT NO. 111.

In this experiment the 1,000 grams of meat was cut into cubes and placed in vigorously boiling distilled water. The temperature of the water was maintained at the boiling point for ten minutes, when the lamp was removed and the temperature allowed to fall to 85° C. The cooking was further continued for five hours at a temperature varying between 84° and 85° C.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	1,000.00
Weight of meat after cooking	do	530.59
Loss in weight in cooking	do	469.41
Loss in weight in cooking	per cent	46.94

The results of the experiment are shown in Tables 9 and 10.

TABLE 9.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 111.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1647	Beef, round, uncooked	74.18	18.11	1.41	1.95	4.28	1.28	27.03	3.350
1644	Beef, round, cooked	59.12	34.14	.40	.57	5.75	.69	41.55	5.590
1644	Broth (per cent uncooked meat)		.56	.92	1.20	.85	.70	4.23	.384
	ON WATER-FREE BASIS.								
1647	Beef, round, uncooked		70.14	5.46	7.55	16.58	4.96	104.69	12.979
1644	Beef, round, cooked		83.51	.98	1.39	14.07	1.69	101.64	13.674
1644	Broth (per cent uncooked meat)		2.18	3.55	4.63	3.29	2.71	16.36	1.487

Table 9.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No 111*—Continued.

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1647	Beef, round, uncooked	....	1.82	1.41	1.95	0	0.94	6.12	0.744
1644	Beef, round, cooked	....	.29	.40	.57	0	.38	1.64	.174
1644	Broth (per cent uncooked meat)	....	.22	.92	1.20	0	.70	3.04	.329
	ON WATER-FREE BASIS.								
1647	Beef, round, uncooked	....	7.05	5.46	7.55	0	3.64	23.70	2.881
1644	Beef, round, cooked	....	.71	.98	1.39	0	.93	4.01	.425
1644	Broth (per cent uncooked meat)	....	.85	3.55	4.63	0	2.71	11.74	1.274

C. NUTRIENTS INSOLUBLE IN COLD WATER.

	ON FRESH BASIS.								
1647	Beef, round, uncooked	....	16.29	0	0	4.28	0.34	20.91	2.606
1644	Beef, round, cooked	....	33.85	0	0	5.75	.31	39.91	5.416
1644	Broth (per cent uncooked meat)	....	.34	0	0	.85	....	1.19	.045
	ON WATER-FREE BASIS.								
1647	Beef, round, uncooked	....	63.09	0	0	16.58	1.32	80.99	10.098
1644	Beef, round, cooked	....	82.80	0	0	14.07	.76	97.63	13.249
1644	Broth (per cent uncooked meat)	....	1.33	0	0	3.29	....	4.62	.213

Table 10.—*Results of cooking (boiling) experiment No. 111.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1644	In cooked meat	313.68	181.14	2.12	3.02	30.51	3.66
1644	In broth	427.17	5.64	9.16	11.95	8.50	6.99
1647	In uncooked meat	740.85	186.78	11.28	14.97	39.01	10.65
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1644	In cooked meat	42.34	96.98	18.79	20.18	78.21	34.37
1644	In broth	57.66	3.02	81.21	79.82	21.79	65.64
1644	In broth on basis of total weight of uncooked meat	42.72	.56	.92	1.20	.85	.70

Cooking Experiment No. 112.

The beef round in the form of cubes was cooked by placing the entire portion of 1,000 grams in 2,000 cubic centimeters of cold water. The water surrounding the meat was gently warmed, one hour being required to raise its temperature to 85° C. The cooking was then continued further at 85° C. for five hours.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	1,000.00
Weight of meat after cooking	do	503.59
Loss in weight in cooking	do	496.41
Loss in weight in cooking	per cent	49.64

The details of the experiment are shown in Tables 11 and 12.

Table 11.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 112.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1647	Beef, round, uncooked	74.18	18.11	1.41	1.95	4.28	1.28	27.03	3.350
1645	Beef, round, cooked	59.84	33.23	.32	.43	5.23	.51	39.75	5.120
1645	Broth (percent uncooked meat)	....	.80	.99	1.27	1.14	.72	4.92	.446
	ON WATER-FREE BASIS.								
1647	Beef, round, uncooked	....	70.14	5.46	7.55	16.58	4.96	104.69	12.979
1645	Beef, round, cooked	....	82.74	.80	1.07	13.02	1.34	98.97	13.496
1645	Broth (percent uncooked meat)	....	3.10	3.84	4.91	4.42	2.80	19.07	1.726
	B. NUTRIENTS SOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1647	Beef, round, uncooked	....	1.82	1.41	1.95	0	0.91	6.12	0.744
1645	Beef, round, cooked	....	.36	.32	.43	0	.34	1.45	.161
1645	Broth (percent uncooked meat)	....	.15	.99	1.27	0	.72	3.13	.341
	ON WATER-FREE BASIS.								
1647	Beef, round, uncooked	....	7.05	5.46	7.55	0	3.64	23.70	2.881
1645	Beef, round, cooked	....	.89	.80	1.07	0	.84	3.59	.401
1645	Broth (percent uncooked meat)	....	.57	3.84	4.91	0	2.80	12.12	1.321
	C. NUTRIENTS INSOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1647	Beef, round, uncooked	....	16.29	0	0	4.28	0.34	20.91	2.606
1645	Beef, round, cooked	....	32.87	0	0	5.23	.20	38.30	5.259
1645	Broth (percent uncooked meat)	....	.65	0	0	1.14	....	1.79	.105
	ON WATER-FREE BASIS.								
1647	Beef, round, uncooked	....	63.09	0	0	16.58	1.32	80.99	10.098
1645	Beef, round, cooked	....	81.85	0	0	13.02	.50	95.37	13.095
1645	Broth (percent uncooked meat)	....	2.53	0	0	4.42	....	6.95	.405

Table 12.—*Results of cooking (boiling) experiment No. 112.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1645	In cooked meat	301.35	167.34	1.61	2.17	26.34	2.72
1645	In broth	447.18	8.00	9.90	12.67	11.42	7.24
1647	In uncooked meat	748.53	175.34	11.51	14.84	37.76	9.96
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1645	In cooked meat	40.26	95.44	13.99	14.62	69.76	27.31
1645	In broth	59.74	4.56	86.01	85.38	30.24	72.69
1645	In broth on basis of total weight of uncooked meat	44.72	.80	.99	1.27	1.14	.72

COOKING EXPERIMENT NO. 113.

The meat cut into cubes was placed in 2,000 cubic centimeters of cold water which was warmed very slowly, requiring one hour to reach 65° C. The cooking was then continued at 64 to 66° C. for five hours.

The losses in weight during the cooking were as follows:

Weight of meat before cooking	grams..	1,000.00
Weight of meat after cooking	do....	548.61
Loss in weight in cooking	do....	451.39
Loss in weight in cooking	per cent..	45.14

The detailed results of the experiment are shown in Tables 13 and 14.

TABLE 13.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 113.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1647	Beef, round, uncooked	74.18	18.11	1.41	1.95	4.28	1.28	27.03	3.350
1646	Beef, round, cooked	62.93	32.16	.29	.38	5.57	.55	38.95	5.240
1646	Broth (percent uncooked meat)		.91	.92	1.19	.70	.74	4.46	.439
	ON WATER-FREE BASIS.								
1647	Beef, round, uncooked		70.14	5.46	7.55	16.58	4.96	104.69	12.979
1646	Beef, round, cooked		86.76	.78	1.03	15.03	1.48	105.08	14.135
1646	Broth (percent uncooked meat)		3.51	3.55	4.63	2.71	2.86	17.26	1.701

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1647	Beef, round, uncooked		1.82	1.41	1.95	0	0.94	6.12	0.744
1646	Beef, round, cooked		.27	.29	.38	0	.24	1.18	.138
1646	Broth (percent uncooked meat)		.23	.92	1.19	0	.74	3.08	.331
	ON WATER-FREE BASIS.								
1647	Beef, round, uncooked		7.05	5.46	7.55	0	3.64	23.70	2.881
1646	Beef, round, cooked		.73	.78	1.03	0	.65	3.19	.372
1646	Broth (percent uncooked meat)		.90	3.55	4.63	0	2.86	11.94	1.283

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1647	Beef, round, uncooked		16.29	0	0	4.28	0.34	20.91	2.606
1646	Beef, round, cooked		31.89	0	0	5.57	.31	37.77	5.102
1646	Broth (percent uncooked meat)		.68	0	0	.70	....	1.38	.108
	ON WATER-FREE BASIS.								
1647	Beef, round, uncooked		63.09	0	0	16.58	1.32	80.99	10.098
1646	Beef, round, cooked		86.03	0	0	15.03	.83	101.89	13.763
1646	Broth (percent uncooked meat)		2.61	0	0	2.71	....	5.32	.418

Table 14.—*Results of cooking (boiling) experiment No 113.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1646	In cooked meat	345.24	176.13	1.59	2.08	30.56	3.02
1646	In broth	406.83	9.06	9.18	11.94	7.00	7.38
1647	In uncooked meat	752.07	185.19	10.77	14.02	37.56	10.40
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1646	In cooked meat	45.91	95.12	14.76	14.84	81.36	29.04
1646	In broth	54.09	4.88	85.24	85.16	18.64	70.96
1646	In broth on basis of total weight of uncooked meat	40.68	.91	.92	1.19	.70	.74

SERIES IV.—EXPERIMENTS NOS. 131, 132.

The special object of these two experiments was to determine the nature and amount of losses and the character of the changes which lean beef round undergoes when cooked in hot water (1) at 85° C.—that is, at a temperature considerably lower than that of boiling water—and (2) at the temperature of boiling water. Lean beef round was selected, and all the bone and visible gristle but none of the fat was removed. The entire portion was cut into small pieces, 0.5 to 0.75 inch thick and 0.75 inch to 1.25 inches long, and was then very thoroughly mixed. Three samples were then taken, two (Nos. 1720 and 1721) for the cooking test and one (No. 1722) for an analysis of the raw meat.

COOKING EXPERIMENT NO. 131.

In the first experiment, No. 131, the meat was plunged into 2,000 cubic centimeters of vigorously boiling water and cooked at the boiling point of water for ten minutes, when the temperature was allowed to drop to 85° C. and the cooking continued until the total time of cooking equaled five hours.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	1,000.00
Weight of meat after cooking	do	551.91
Loss in weight in cooking	do	448.09
Loss in weight in cooking	per cent	44.81

Tables 15 and 16 show the details of the experiment.

Table 15.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 131.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1722	Beef, round, uncooked	72.57	18.96	1.12	1.99	4.78	1.09	27.91	3.392
1720	Beef, round, cooked	55.31	31.88	.65	.15	11.61	.51	44.80	5.309
1720	Broth (percent uncooked meat)	....	.42	.95	1.34	1.26	.64	4.61	.372
	ON WATER-FREE BASIS.								
1722	Beef, round, uncooked	....	69.12	4.08	7.25	17.43	3.97	101.85	12.366
1720	Beef, round, cooked	....	71.31	1.45	.34	25.98	1.14	100.25	11.880
1720	Broth (percent uncooked meat)	....	1.55	3.46	4.87	4.61	2.33	16.82	1.356

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1722	Beef, round, uncooked	....	2.70	1.12	1.99	0	0.89	6.70	0.791
1720	Beef, round, cooked	....	.16	.65	.15	0	.25	1.21	.234
1720	Broth (percent uncooked meat)	....	.28	.95	1.34	0	.64	3.21	.350
	ON WATER-FREE BASIS.								
1722	Beef, round, uncooked	....	9.86	4.08	7.25	0	3.25	24.44	2.885
1720	Beef, round, cooked	....	.36	1.45	.34	0	.57	2.72	.524
1720	Broth (percent uncooked meat)	....	1.05	3.46	4.87	0	2.32	11.70	1.276

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1722	Beef, round, uncooked	....	16.26	0	0	4.78	0.20	21.24	2.601
1720	Beef, round, cooked	....	31.72	0	0	11.61	.26	43.59	5.075
1720	Broth (percent uncooked meat)	....	.14	0	0	1.26	....	1.40	.022
	ON WATER-FREE BASIS.								
1722	Beef, round, uncooked	....	59.26	0	0	17.43	.72	77.41	9.481
1720	Beef, round, cooked	....	70.98	0	0	25.98	.57	97.53	11.356
1720	Broth (percent uncooked meat)	....	.50	0	0	4.61	.01	5.12	.080

Table 16.—*Results of cooking (boiling) experiment No. 131.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1720	In cooked meat	305.26	175.95	3.59	0.83	64.08	2.81
1720	In broth	401.97	4.24	9.49	13.36	12.64	6.39
1722	In uncooked meat	707.23	180.19	13.08	14.19	76.72	9.20
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1720	In cooked meat	43.16	97.65	27.45	5.85	83.52	30.54
1720	In broth	56.84	2.35	72.55	94.15	16.48	69.46
1720	In broth on basis of total weight of uncooked meat	40.20	.42	.95	1.34	1.26	.64

COOKING EXPERIMENT No. 132.

The meat used in this experiment was placed directly in 2,000 cubic centimeters of vigorously boiling water and cooked at this temperature for five hours.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams..	1,000.00
Weight of meat after cooking	do....	549.72
Loss in weight in cooking	do....	450.28
Loss in weight in cooking	per cent..	45.03

The details of the experiment are recorded in Tables 17 and 18.

TABLE 17.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 132.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.								
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1722	Beef, round, uncooked	72.57	18.96	1.12	1.99	4.78	1.09	27.94	3.392
1721	Beef, round, cooked	57.12	31.98	.65	.50	9.01	.63	42.77	5.324
1721	Broth (percent uncooked meat)	....	.71	.88	1.27	1.14	.59	4.59	.395
	ON WATER-FREE BASIS.								
1722	Beef, round, uncooked	....	69.12	4.08	7.25	17.43	3.97	101.85	12.366
1721	Beef, round, cooked	....	74.58	1.51	1.17	21.01	1.47	99.71	12.416
1721	Broth (percent uncooked meat)	....	2.57	3.21	4.64	4.14	2.15	16.71	1.441

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.								
1722	Beef, round, uncooked	....	2.70	1.12	1.99	0	0.89	6.70	0.791
1721	Beef, round, cooked	....	.56	.65	.50	0	.38	2.09	.297
1721	Broth (percent uncooked meat)	....	.60	.88	1.27	0	.59	3.34	.379
	ON WATER-FREE BASIS.								
1722	Beef, round, uncooked	....	9.86	4.08	7.25	0	3.25	24.44	2.885
1721	Beef, round, cooked	....	1.31	1.51	1.17	0	.90	4.89	.694
1721	Broth (percent uncooked meat)	....	2.19	3.21	4.64	0	2.15	12.19	1.380

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.								
1722	Beef, round, uncooked	....	16.26	0	0	4.78	0.20	21.24	2.601
1721	Beef, round, cooked	....	31.42	0	0	9.01	.25	40.68	5.027
1721	Broth (percent uncooked meat)	....	.11	0	0	1.14	....	1.25	.016
	ON WATER-FREE BASIS.								
1722	Beef, round, uncooked	....	59.26	0	0	17.43	.72	77.41	9.481
1721	Beef, round, cooked	....	73.27	0	0	21.01	.57	94.85	11.722
1721	Broth (percent uncooked meat)	....	.38	0	0	4.14	....	4.52	.061

Table 18.—*Results of cooking (boiling) experiment No. 132.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogeneous.	Non-nitrogeneous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1721	In cooked meat	314.00	175.80	3.57	2.75	49.53	3.46
1721	In broth	404.42	7.05	8.81	12.74	11.35	5.91
1722	In uncooked meat	718.42	182.85	12.38	15.19	60.88	9.37
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1721	In cooked meat	43.71	96.14	28.81	17.75	81.36	36.93
1721	In broth	56.29	3.86	71.16	82.25	18.61	63.07
1721	In broth on basis of total weight of uncooked meat	40.44	.71	.88	1.27	1.14	.59

SERIES V.—EXPERIMENTS NOS. 125, 126.

The special object in these experiments was to study the changes produced in fat beef rump by cooking in water (1) at 85° C.—that is, considerably under the boiling point of water—and (2) at the boiling point of water. Before cooking, the beef rump was freed from all bone and gristle but none of the fat was removed. It was then divided into pieces, 0.5 to 0.75 inch thick and 0.75 inch to 1.25 inches long. After a thorough mixing, two portions (Nos. 1703 and 1704) each weighing 1,000 grams, were taken for cooking, while a third (No. 1705) was reserved for analysis.

COOKING EXPERIMENT NO. 125.

The first portion in the test, the cubes of meat (sample No. 1703) were placed in 2,000 cubic centimeters of vigorously boiling water. The temperature was kept at 99.5° C. for ten minutes, then allowed to drop to 85° C., at which temperature the cooking continued until the meat had been cooked for five hours in all.

The losses in weight in cooking were as follows:

Weight of meat before cooking	grams	1,000.00
Weight of meat after cooking	do	595.32
Loss in weight in cooking	do	404.68
Loss in weight in cooking	per cent	40.47

Tables 19 and 20 give the details of the experiment.

TABLE 19.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 125.*

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.								
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct*	*Per ct.*	*Per ct.*	*Per ct.*
1705	Beef, rump, uncooked	61.22	17.71	......	......	20.23	0.91	38.85	2.834
1703	Beef, rump, cooked	48.31	27.13	0.29	0.31	23.36	.43	51.55	4.133
1703	Broth (percent uncooked meat)		.45	.86	1.03	2.36	.59	5.29	.318
	ON WATER-FREE BASIS.								
1705	Beef, rump, uncooked		45.67	......	......	52.17	2.35	100.19	7.308
1703	Beef, rump, cooked		52.52	.56	.66	45.22	.83	99.79	8.581
1703	Broth (percent uncooked meat)		1.15	2.23	2.65	6.08	1.53	13.64	.897
	B. NUTRIENTS SOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1705	Beef, rump, uncooked		......	......	......	......	......	......	......
1703	Beef, rump, cooked		0.38	0.29	0.31	0	0.28	1.29	0.151
1703	Broth (percent uncooked meat)		.31	.86	1.03	0	.59	2.82	.331
	ON WATER FREE BASIS.								
1705	Beef, rump, uncooked		......	......	......	......	......	......	......
1703	Beef, rump, cooked		.71	.56	.66	0	.54	2.50	.297
1703	Broth (percent uncooked meat)		.87	2.23	2.65	0	1.53	7.28	.855
	C. NUTRIENTS INSOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1705	Beef, rump, uncooked		......	......	......	......	......	......	......
1703	Beef, rump, cooked		26.75	0	0	23.36	0.15	50.26	4.279
1703	Broth (percent uncooked meat)		.11	0	0	2.36	......	2.47	.017
	ON WATER-FREE BASIS.								
1705	Beef, rump, uncooked		......	......	......	......	......	......	......
1703	Beef, rump, cooked		51.78	0	0	45.22	.29	97.29	8.284
1703	Broth (percent uncooked meat)		.28	0	0	6.08	......	6.36	.042

TABLE 20.—*Results of cooking (boiling) experiment No. 125.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1703	In cooked meat	287.78	161.51	1.73	2.02	139.07	2.56
1703	In broth	351.80	4.45	8.63	10.27	23.59	5.94
1705	In uncooked meat	639.58	165.96	10.36	12.29	162.66	8.50
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1703	In cooked meat	45.00	97.32	16.70	16.44	85.50	30.12
1703	In broth	55.00	2.68	83.30	83.56	14.50	69.88
1703	In broth on basis of total weight of uncooked meat	35.18	.45	.86	1.03	2.36	.59

COOKING EXPERIMENT No. 126.

In this test the small pieces of beef rump (sample No. 1704) were put into 2,000 cubic centimeters of vigorously boiling water and cooked for five hours.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams..	1,000.00
Weight of meat after cooking	do....	565.45
Loss in weight in cooking	do....	434.55
Loss in weight in cooking	per cent..	43.46

Tables 21 and 22 show the details of the experiment.

TABLE 21.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 126.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1705	Beef, rump, uncooked	61.22	17.71	....	....	20.23	0.91	38.85	2.834
1704	Beef, rump, cooked	55.01	27.58	0.53	0.72	16.07	.68	45.58	4.583
1704	Broth (percent uncooked meat)	....	1.01	.75	.94	3.09	.53	6.31	.401
	ON WATER-FREE BASIS.								
1705	Beef, rump, uncooked	....	45.67	....	....	52.17	2.35	100.19	7.308
1704	Beef, rump, cooked	....	61.30	1.18	1.60	35.72	1.51	101.31	10.190
1704	Broth (percent uncooked meat)	....	2.61	1.92	2.43	7.96	1.36	16.28	1.035

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1705	Beef, rump, uncooked	....	....	....	....	....	....	....	....
1704	Beef, rump, cooked	....	0.90	0.53	0.72	0	0.47	2.62	0.315
1704	Broth (percent uncooked meat)	....	.88	.75	.91	0	.53	3.10	.379
	ON WATER-FREE BASIS.								
1705	Beef, rump, uncooked	....	....	....	....	....	....	....	....
1704	Beef, rump, cooked	....	2.00	1.18	1.60	0	1.04	5.82	.699
1704	Broth (percent uncooked meat)	....	2.26	1.92	2.43	0	1.36	7.97	.979

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1705	Beef, rump, uncooked	....	....	....	....	....	....	....	....
1704	Beef, rump, cooked	....	26.68	0	0	16.07	0.21	42.96	4.268
1704	Broth (percent uncooked meat)	....	.13	0	0	3.09	....	3.21	.022
	ON WATER-FREE BASIS.								
1705	Beef, rump, uncooked	....	....	....	....	....	....	....	....
1704	Beef, rump, cooked	....	59.30	0	0	35.72	.47	95.49	9.491
1704	Broth (percent uncooked meat)	....	.35	0	0	7.96	....	8.31	.056

TABLE 22.—*Results of cooking (boiling) experiment No. 126.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1704	In cooked meat	311.05	155.95	3.00	4.07	90.87	3.85
1704	In broth	371.44	10.11	7.45	9.40	30.87	5.28
1705	In uncooked meat	682.49	166.06	10.45	13.47	121.74	9.13
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1704	In cooked meat	45.58	93.91	28.70	30.22	71.64	42.17
1704	In broth	54.42	6.09	71.30	69.78	25.36	57.83
1704	In broth on basis of total weight of uncooked meat	37.11	1.01	.75	.91	3.09	.53

SERIES VI. EXPERIMENTS NOS. 114-116.

These three experiments were planned to determine the effect of variations in time, temperature, and procedure of cooking upon the amount and composition of the materials which pass into the broth. Lean veal leg, freed from bone, visible gristle, and most of the visible fat, was divided into pieces 0.5 to 0.75 inch thick and 0.75 to 1.25 inches long and, after thorough mixing, was divided into four samples, weighing 1,000 grams each (Nos. 1652, 1653, and 1654) for the cooking test and one (No. 1656) for analysis.

COOKING EXPERIMENT NO. 114.

The cubes of veal were plunged into vigorously boiling water and cooked for five hours in gently boiling water.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	1,000.00
Weight of meat after cooking	do	591.61
Loss in weight in cooking	do	408.39
Loss in weight in cooking	per cent	40.84

Tables 23 and 24 show the results of the experiment in detail.

TABLE 23.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 114.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1656	Veal, leg, uncooked	75.97	19.17	1.26	1.91	0.96	1.15	24.48	3.470
1652	Veal, leg, cooked	64.73	30.95	1.12	1.67	1.59	1.01	36.34	5.310
1652	Broth (per cent uncooked meat)	....	.68	.67	.96	.07	.51	2.89	.323
	ON WATER-FREE BASIS.								
1656	Veal, leg, uncooked	....	79.77	5.24	8.07	3.99	4.79	101.86	14.440
1652	Veal, leg, cooked	....	87.75	3.18	4.74	4.51	2.86	103.04	15.055
1652	Broth (per cent uncooked meat)	....	2.84	2.78	3.99	.28	2.12	12.01	1.345

TABLE 23.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 114*—Continued.

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1656	Veal, leg, uncooked		2.83	1.26	1.91	0	1.00	7.03	0.855
1652	Veal, leg, cooked		.44	1.12	1.67	0	.73	3.96	.428
1652	Broth (percent uncooked meat)		.54	.67	.96	0	.51	2.68	.301
	ON WATER-FREE BASIS.								
1656	Veal, leg, uncooked		11.78	5.24	8.07	0	1.16	29.25	3.558
1652	Veal, leg, cooked		1.25	3.18	4.71	0	2.07	11.24	1.215
1652	Broth (percent uncooked meat)		2.26	2.78	3.99	0	2.11	11.14	1.254

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.								
1656	Veal, leg, uncooked		16.34	0	0	0.96	0.15	17.45	2.615
1652	Veal, leg, cooked		30.51	0	0	1.59	.28	32.38	1.882
1652	Broth (percent uncooked meat)		.14	0	0	.07	....	.21	.022
	ON WATER-FREE BASIS.								
1656	Veal, leg, uncooked		67.99	0	0	3.99	.63	72.61	10.882
1652	Veal, leg, cooked		86.50	0	0	4.51	.79	91.80	13.840
1652	Broth (percent uncooked meat)		.58	0	0	.28	.01	.87	.091

TABLE 24.—*Results of cooking (boiling) experiment No. 114.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams*	*Grams.*	*Grams.*	*Grams.*
1652	In cooked meat	382.95	183 10	6.63	9.88	9.41	5.98
1652	In broth	379.55	6.81	6.68	9.58	.68	5.09
1656	In uncooked meat	762.50	189.91	13 31	19 46	10.09	11.07
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*	*Per cent*	*Per ct.*
1652	In cooked meat	50 22	96.41	19.81	50.77	93.26	54.02
1652	In broth	49.78	3.59	50.19	49.23	6.74	45.98
1652	In broth on basis of total weight of uncooked meat	37.96	.68	.67	.96	.07	.51

COOKING EXPERIMENT No. 115.

In this test the veal leg, cut into cubes, was quickly immersed in 2,000 cubic centimeters of vigorously boiling distilled water. The water was kept as near the boiling point as possible for ten minutes, the temperature then allowed to drop to 85° C., and the cooking continued at a temperature varying between 84° and 85° C.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams..	1,000.00
Weight of meat after cooking	do....	591.06
Loss in weight in cooking	do....	408.94
Loss in weight in cooking	per cent..	40.89

The detailed results of the experiment are shown in Tables 25 and 26.

TABLE 25.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 115.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1656	Veal, leg, uncooked	75.97	19.17	1.26	1.91	0.96	1.15	24.48	3.470
1653	Veal, leg, cooked	66.65	32.11	.69	1.00	1.31	.75	35.86	5.360
1653	Broth (percent uncooked meat	....	.51	.85	1.13	.06	.62	3.17	.351
	ON WATER-FREE BASIS.								
1656	Veal, leg, uncooked	......	79.77	5.24	8.07	3.99	4.79	101.86	14.440
1653	Veal, leg, cooked	......	96.28	2.07	3.00	3.93	2.25	107.53	16.072
1653	Broth (percent uncooked meat	....	2.12	3.52	4.70	.24	2.66	13.18	1.473

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1656	Veal, leg, uncooked		2.83	1.26	1.91	0	1.00	7.03	0.855
1653	Veal, leg, cooked		.19	.69	1.00	0	.60	2.78	.301
1653	Broth (percent uncooked meat)		.27	.85	1.13	0	.62	2.87	.315
	ON WATER-FREE BASIS.								
1656	Veal, leg, uncooked		11.78	5.24	8.07	0	4.16	29.25	3.558
1653	Veal, leg, cooked		1.47	2.07	3.00	0	1.80	8.34	.903
1653	Broth (percent uncooked meat)		1.14	3.52	4.70	0	2.60	11.96	1.311

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1656	Veal, leg, uncooked		16.34	0	0	0.96	0.15	17.45	2.615
1653	Veal, leg, cooked		31.62	0	0	1.31	.15	33.08	5.059
1653	Broth (percent uncooked meat)		.24	0	0	.06	....	.30	.039
	ON WATER-FREE BASIS.								
1656	Veal, leg, uncooked		67.99	0	0	3.99	.63	72.61	10.882
1653	Veal, leg, cooked		91.81	0	0	3.93	.45	99.19	15.169
1653	Broth (percent uncooked meat)		.98	0	0	.24	....	1.22	.162

TABLE 26.—*Results of cooking (boiling) experiment No. 115.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1653	In cooked meat	393.94	189.79	4.08	5.91	7.74	4.43
1653	In broth	377.26	5.10	8.46	11.31	.57	6.24
1656	In uncooked meat	771.20	194.89	12.54	17.22	8.31	10.67
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1653	In cooked meat	51.08	97.38	32.54	34.32	93.14	41.52
1653	In broth	48.92	2.62	67.46	65.68	6.86	58.48
1653	In broth on basis of total weight of uncooked meat	37.73	.51	.85	1.13	.06	.62

COOKING EXPERIMENT No. 116.

In this test the portion of veal leg was placed in 2,000 cubic centimeters of cold water. The temperature was then gradually raised, reaching 85° C. in an hour and the cooking continued for five hours at this temperature.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	1,000.00
Weight of meat after cooking	do	586.78
Loss in weight in cooking	do	413.22
Loss in weight in cooking	per cent	41.32

Tables 27 and 28 show the details of the experiment.

TABLE 27.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 116.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.								
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1656	Veal, leg, uncooked	75.97	19.17	1.26	1.94	0.96	1.15	21.48	3.470
1654	Veal, leg, cooked	68.59	31.10	.29	.96	.97	.64	33.96	5.070
1654	Broth (percent uncooked meat)		1.01	.76	1.14	.19	.62	3.72	.404
	ON WATER-FREE BASIS.								
1656	Veal, leg, uncooked		79.77	5.24	8.07	3.99	4.79	101.86	14.440
1654	Veal, leg, cooked		99.01	.92	3.06	3.09	2.04	108.12	16.140
1654	Broth (percent uncooked meat)		4.21	3.15	4.73	.78	2.60	15.47	1.683

B. NUTRIENTS SOLUBLE IN COLD WATER.

	ON FRESH BASIS.								
1656	Veal, leg, uncooked		2.83	1.26	1.94	0	1.00	7.03	0.855
1654	Veal, leg, cooked		.60	.29	.96	0	.50	2.35	.189
1654	Broth (percent uncooked meat)		.41	.76	1.14	0	.62	2.93	.307
	ON WATER-FREE BASIS.								
1656	Veal, leg, uncooked		11.78	5.24	8.07	0	4.16	29.25	3.558
1654	Veal, leg, cooked		1.89	.92	3.06	0	1.59	7.46	.602
1654	Broth (percent uncooked meat)		1.68	3.15	4.73	0	2.59	12.15	1.278

C. NUTRIENTS INSOLUBLE IN COLD WATER.

	ON FRESH BASIS.								
1656	Veal, leg, uncooked		16.34	0	0	0.96	0.15	17.45	2.615
1654	Veal, leg, cooked		30.50	0	0	.97	.14	31.61	4.881
1654	Broth (percent uncooked meat)		.60	0	0	.19	......	.79	.097
	ON WATER-FREE BASIS.								
1656	Veal, leg, uncooked		67.99	0	0	3.99	.63	72.61	10.882
1654	Veal, leg, cooked		97.12	0	0	3.09	.45	100.66	15.538
1654	Broth (percent uncooked meat)		2.53	0	0	.78	.01	3.32	.405

TABLE 28.—*Results of cooking (boiling) experiment No. 116.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1654	In cooked meat	402.17	182.19	1.70	5.63	5.69	3.76
1654	In broth	376.05	10.12	7.56	11.37	1.88	6.21
1656	In uncooked meat	778.52	192.61	9.26	17.00	7.57	10.00
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1654	In cooked meat	51.70	94.75	18.36	33.12	75.17	37.60
1654	In broth	48.30	5.25	81.64	66.88	21.83	62.10
1654	In broth on basis of total weight of uncooked meat	37.61	1.01	.76	1.14	.19	.62

MEATS COOKED BY BOILING COMPARED WITH THOSE COOKED BY DRY HEAT.

SERIES VII.—EXPERIMENTS NOS. 117-120.

The object of this series of four cooking experiments made with the same cut of veal was to determine the nature of the changes in nutritive value and the character and extent of the losses which take place when veal is cooked (1) by immersing in boiling water for ten minutes and then continuing the cooking at 85° C. for five hours; (2) by putting it in cold water and warming gradually, allowing one hour to reach a temperature of 85° C., and continuing the cooking at 85° C. for five hours; (3) by pan broiling for fifteen minutes, and (4) by roasting in the form of a loaf. The entire cut of fresh veal leg, after freeing it from all bone and visible gristle, was cut into pieces 0.5 to 0.75 inch thick and from 0.75 to 1.25 inches long, thoroughly mixed and divided carefully into five portions weighing 1,000 grams each, four (Nos. 1664, 1658, 1659, and 1660) to be used for the cooking tests and one (1662) for analysis.

COOKING EXPERIMENT NO. 117.

For this experiment one of the portions of the veal was plunged into 2,000 cubic centimeters of rapidly boiling water, the temperature kept as near the boiling point as possible for ten minutes and then allowed to fall to 85° C., at which temperature the meat was further cooked for five hours.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	1,000.00
Weight of meat after cooking	do	590.40
Loss in weight in cooking	do	409.60
Loss in weight in cooking	per cent	40.96

The details of the experiment are recorded in Tables 29 and 30.

Table 29.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 117.*

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.								
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1662	Veal, leg, uncooked	75.53	18.02	1.08	1.37	3.99	1.10	25.56	3.230
1664	Veal, leg, cooked	61.87	29.53	.55	.77	7.77	.66	39.28	4.900
1664	Broth (percent uncooked meat)		.64	.78	.91	.33	.62	3.28	.351
	ON WATER-FREE BASIS.								
1662	Veal, leg, uncooked		73.64	4.41	5.60	16.31	4.49	104.45	13.200
1664	Veal, leg, cooked		77.45	1.47	1.99	20.38	1.73	103.02	12.851
1664	Broth (percent uncooked meat)		2.60	3.18	3.73	1.35	2.52	13.38	1.434
	B. NUTRIENTS SOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1662	Veal, leg, uncooked		1.90	1.08	1.37	0	0.91	5.26	0.650
1664	Veal, leg, cooked		.32	.55	.77	0	.53	2.17	.227
1664	Broth (percent uncooked meat)		.50	.78	.91	0	.62	2.81	.329
	ON WATER-FREE BASIS.								
1662	Veal, leg, uncooked		7.76	4.41	5.60	0	3.72	21.49	2.658
1664	Veal, leg, cooked		.81	1.47	1.99	0	1.39	5.69	.595
1664	Broth (percent uncooked meat)		2.04	3.18	3.73	0	2.51	11.46	1.345
	C. NUTRIENTS INSOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1662	Veal, leg, uncooked		16.12	0	0	3.99	0.19	20.30	2.580
1664	Veal, leg, cooked		29.21	0	0	7.77	.13	37.11	4.673
1664	Broth (percent uncooked meat)		.14	0	0	.33	....	.47	.022
	ON WATER-FREE BASIS.								
1662	Veal, leg, uncooked		65.88	0	0	16.31	.77	82.96	10.542
1664	Veal, leg, cooked		76.61	0	0	20.38	.34	97.33	12.256
1664	Broth (percent uncooked meat)		.56	0	0	1.35	.01	1.92	.089

Table 30.—*Results of cooking (boiling) experiment No. 117.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1664	In cooked meat	365.28	174.35	3.25	4.55	45.87	3.90
1664	In broth	376.88	6.36	7.77	9.12	3.31	6.16
1662	In uncooked meat	742.16	180.71	11.08	13.61	49.18	10.06
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1664	In cooked meat	49.22	96.48	29.87	32.99	93.27	38.77
1661	In broth	50.78	3.52	70.13	67.01	6.73	61.23
1664	In broth on basis of total weight of uncooked meat	37.69	.64	.78	.91	.33	.62

COOKING EXPERIMENT No. 118.

In this test one portion of the veal (sample No. 1658) was put into 2,000 cubic centimeters of cold distilled water. The temperature was gradually increased, reaching 85° C in an hour, and the cooking continued at this temperature for five hours.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	1,000.00
Weight of meat after cooking	do	574.94
Loss in weight in cooking	do	425.06
Loss in weight in cooking	per cent	42.51

Tables 31 and 32 show the detailed results of the experiment.

TABLE 31.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 118.*

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.								
	ON FRESH BASIS.								
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1662	Veal, leg, uncooked	75.53	18.02	1.08	1.37	3.99	1.10	25.56	3.230
1658	Veal, leg, cooked	64.66	29.13	.44	.55	5.58	.59	36.29	1.800
1658	Broth (percent uncooked meat)		1.02	.79	.96	.50	.63	3.90	.117
	ON WATER-FREE BASIS.								
1662	Veal, leg, uncooked		73.64	4.41	5.60	16.31	1.49	104.45	13.200
1658	Veal, leg, cooked		82.43	1.25	1.55	15.79	1.67	102.69	13.582
1658	Broth (percent uncooked meat)		4.18	3.23	3.92	2.03	2.59	15.95	1.704
	B. NUTRIENTS SOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1662	Veal, leg, uncooked		1.90	1.08	1.37	0	0.91	5.26	0.650
1658	Veal, leg, cooked		.31	.44	.55	0	.10	1.70	.190
1658	Broth (percent uncooked meat)		.45	.79	.96	0	.63	2.83	.326
	ON WATER-FREE BASIS.								
1662	Veal, leg, uncooked		7.76	4.41	5.60	0	3.72	21.49	2.658
1658	Veal, leg, cooked		.91	1.25	1.55	0	1.13	4.81	.571
1658	Broth (percent uncooked meat)		1.85	3.23	3.92	0	2.58	11.58	1.332
	C. NUTRIENTS INSOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1662	Veal, leg, uncooked		16.12	0	0	3.99	0.19	20.30	2.580
1658	Veal, leg, cooked		28.82	0	0	5.58	.19	34.59	1.610
1658	Broth (percent uncooked meat)		.57	0	0	.50	......	1.07	.091
	ON WATER-FREE BASIS.								
1662	Veal, leg, uncooked		65.88	0	0	16.31	.77	82.96	10.542
1658	Veal, leg, cooked		81.52	0	0	15.79	.54	97.85	13.011
1658	Broth (percent uncooked meat)		2.33	0	0	2.03	.01	4.37	.372

TABLE 32.—*Results of cooking (boiling) experiment No. 118.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1658	In cooked meat	371.76	167.48	2.53	3.16	32.08	3.39
1658	In broth	386.02	10.22	7.91	9.60	4.98	6.33
1662	In uncooked meat	757.78	177.70	10.44	12.76	37.06	9.72
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1658	In cooked meat	49.06	94.25	21.23	24.76	86.57	34.88
1658	In broth	50.94	5.75	75.77	75.24	13.43	65.12
1658	In broth on basis of total weight of uncooked meat	38.60	1.02	.79	.96	.50	.63

COOKING EXPERIMENT NO. 119.

This is the first experiment reported in this bulletin in which the meat was cooked by pan broiling. The veal (sample No. 1659) was passed through a sausage mill three times and thoroughly mixed each time. It was then made up into cakes weighing 90 to 100 grams each and pan broiled; that is, the meat was placed in a moderately hot, dry, cast-iron pan and cooked over a gas flame for fifteen minutes, or until fairly well done, being turned frequently after it was well seared. The frying pan was not greased, nor was any fat added during the cooking. When cooked, the meat was removed from the frying pan, care being taken to scrape off any adhering material, and weighed.

The difference in weight between the raw and cooked meat showed the total loss resulting from cooking, and the difference between the amount of each ingredient in the uncooked and cooked meat was assumed to represent the losses during cooking. In the tables a loss is indicated by the minus sign (—), and an apparent gain by a plus sign (+),[a] as will be explained (p. 180).

The losses in weight during the cooking were as follows:

Weight of meat before cooking	grams	572.72
Weight of meat after cooking	do	399.37
Loss in weight in cooking	do	173.35
Loss in weight in cooking	per cent	30.27

The results of the experiment are shown in detail in Tables 33 and 34.

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[a] See U. S. Dept. Agr., Office of Experiment Stations Bul. 141, p. 62 et seq.

Table 33.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 119.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.								
		Per. ct.	*Per. ct.*	*Per. ct.*	*Per. ct.*	*Per. ct.*	*Per. ct.*	*Per. ct.*	*Per. ct.*
1662	Veal, leg, uncooked	75.53	18.02	1.08	1.37	3.99	1.10	25.56	3.230
1659	Veal, leg, cooked	65.33	26.71	1.33	1.84	5.20	1.14	36.52	4.700
	ON WATER-FREE BASIS.								
1662	Veal, leg, uncooked		73.64	4.41	5.60	16.31	4.50	104.46	13.200
1659	Veal, leg, cooked		77.04	3.84	5.31	15.00	4.15	105.34	13.556

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1662	Veal, leg, uncooked		1.90	1.08	1.37	0	0.91	5.26	0.650
1659	Veal, leg, cooked		.42	1.33	1.84	0	1.29	4.88	.494
	ON WATER-FREE BASIS.								
1662	Veal, leg, uncooked		7.76	4.41	5.60	0	3.72	21.49	2.658
1659	Veal, leg, cooked		1.21	3.84	5.31	0	3.72	14.08	1.425

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1662	Veal, leg, uncooked		16.12	0	0	3.99	0.19	20.30	2.580
1659	Veal, leg, cooked		26.29	0	0	5.20	.15	31.64	4.206
	ON WATER-FREE BASIS.								
1662	Veal, leg, uncooked		65.88	0	0	16.31	.77	82.96	10.542
1659	Veal, leg, cooked		75.83	0	0	15.00	.43	91.26	12.131

Table 34.—*Results of cooking (panbroiling) experiment No. 119.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1662	In uncooked meat	432.58	103.20	6.19	7.85	22.85	6.30
1659	In cooked meat	260.90	106.67	5.31	7.35	20.77	5.75
	Lost (−) or (apparently) gained (+)	−171.68	+3.47	− .88	− .50	−2.08	− .55
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1659	In cooked meat	60.31	100.00	85.78	93.63	90.90	91.27
	Lost (−) or (apparently) gained (+)	− 39.69	+3.36	−14.22	−6.37	−9.10	−8.73
	Lost (−) or (apparently) gained (+) in percentages of weight of uncooked meat.	− 29.98	+ .61	− .15	− .09	− .36	− .10

COOKING EXPERIMENT No. 120.

The fourth portion (sample No. 1660) of veal leg was passed through a sausage mill three times, being thoroughly mixed each time, then made into a loaf without the addition of seasoning or any other material and carefully and slowly cooked in a gas oven for three hours.

The losses in weight during the cooking were as follows:

Weight of meat before cooking	grams	1,099.00
Weight of meat after cooking	do	854.18
Loss in weight in cooking	do	244.82
Loss in weight in cooking	per cent	22.28

The details of the experiment are recorded in Tables 35 and 36.

TABLE 35.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 120.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1662	Veal, leg, uncooked	75.53	18.02	1.08	1.37	3.99	1.10	25.56	3.230
1660	Veal, leg, cooked	68.35	23.69	1.34	1.89	4.65	1.36	32.93	4.220
	ON WATER-FREE BASIS.								
1662	Veal, leg, uncooked		73.61	4.41	5.60	16.31	4.50	104.46	13.200
1660	Veal, leg, cooked		74.85	4.23	5.97	14.69	4.30	104.01	13.333

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1662	Veal, leg, uncooked		1.90	1.08	1.37	0	0.91	5.26	0.650
1660	Veal, leg, cooked		.41	1.34	1.89	0	1.18	4.82	.496
	ON WATER-FREE BASIS.								
1662	Veal, leg, uncooked		7.76	4.41	5.60	0	3.72	21.49	2.658
1660	Veal, leg, cooked		1.30	4.23	5.97	0	3.73	15.23	1.566

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1662	Veal, leg, uncooked		16.12	0	0	3.99	0.19	20.30	2.580
1660	Veal, leg, cooked		23.28	0	0	4.65	.18	28.11	3.724
	ON WATER-FREE BASIS.								
1662	Veal, leg, uncooked		65.88	0	0	16.31	.77	82.96	10.542
1660	Veal, leg, cooked		73.55	0	0	11.69	.57	88.81	11.767

Table 36.—*Results of cooking (roasting) experiment No. 120.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1662	In uncooked meat	830.07	198.04	11.87	15.06	43.85	12.09
1660	In cooked meat	583.83	202.36	11.45	16.14	39.72	11.62
	Lost (−) or (apparently) gained (+)	−246.24	+4.32	.42	+1.08	4.13	.47
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1660	In cooked meat	70.34	100.00	96.46	100.00	90.58	96.11
	Lost (−) or (apparently) gained (+)	−29.66	+2.18	−3.54	+7.17	9.42	3.89
	Lost (−) or (apparently) gained (+) in percentages of weight of uncooked meat	22.14	+.39	−.04	+.10	.38	−.04

Series VIII.—Experiments Nos. 121–124.

The main object in this series of experiments was to study the losses and to determine the nature of the changes which take place when different cuts of meat—neck, flank, and rump—are cooked by boiling. Further, in one of the tests (No. 124) the meat was pan broiled for the purpose of comparing the effect of this method of cooking with boiling.

Cooking Experiment No. 121.

In this experiment a cut of beef neck freed from all bone and visible gristle but not from the visible fat was cut into 0.7-inch cubes and thoroughly mixed. Two uniform samples were selected, one (No. 1665) for cooking and one (No. 1668) for complete chemical analysis. In the cooking test the weighed meat was placed in 2,000 cubic centimeters of vigorously boiling water, cooked for ten minutes at this temperature and for five hours at 85° C.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	700.00
Weight of meat after cooking	do	384.35
Loss in weight in cooking	do	315.65
Loss in weight in cooking	per cent	45.09

Tables 37 and 38 show the details of the experiment.

TABLE 37.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 121.*

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.								
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1668	Beef, neck, uncooked	71.29	17.75	0.81	1.63	8.77	1.02	29.98	3.098
1665	Beef, neck, cooked	54.40	30.86	.32	.55	13.68	.47	45.88	5.039
1665	Broth (percent uncooked meat)		2.09	(*a*)	(*a*)	1.02	.67	(*a*)	.334
	ON WATER-FREE BASIS.								
1668	Beef, neck, uncooked		61.83	2.82	5.68	30.55	3.55	104.43	10.791
1665	Beef, neck, cooked		67.68	.70	1.21	30.00	1.03	100.62	11.049
1665	Broth (percent uncooked meat)		7.27	(*a*)	(*a*)	3.55	2.34	(*a*)	1.163
	B. NUTRIENTS SOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1668	Beef, neck, uncooked		2.30	0.81	1.63	0	0.77	5.51	0.627
1665	Beef, neck, cooked		.19	.32	.55	0	.20	1.26	.132
1665	Broth (percent uncooked meat)		2.00	(*a*)	(*a*)	0	.67	2.89	.320
	ON WATER-FREE BASIS.								
1668	Beef, neck, uncooked		8.02	2.82	5.68	0	2.68	19.20	2.183
1665	Beef, neck, cooked		.42	.70	1.21	0	.44	2.77	.290
1665	Broth (percent uncooked meat)		6.97	(*a*)	(*a*)	0	2.34	10.07	1.115
	C. NUTRIENTS INSOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1668	Beef, neck, uncooked		15.45	0	0	8.77	0.25	24.47	2.471
1665	Beef, neck, cooked		30.67	0	0	13.68	.27	44.62	4.907
1665	Broth (percent uncooked meat)		.09	0	0	1.02	....	....	.014
	ON WATER-FREE BASIS.								
1668	Beef, neck, uncooked		53.81	0	0	30.55	.87	85.23	8.608
1665	Beef, neck, cooked		67.26	0	0	30.00	.59	97.85	10.759
1665	Broth (percent uncooked meat)		.30	....	....	3.55	....	....	.048

a Determination lost.

TABLE 38.—*Results of cooking (boiling) experiment No. 121.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1665	In cooked meat	209.09	118.61	1.23	2.11	52.58	1.81
1665	In broth	(*a*)	11.63	(*a*)	(*a*)	7.12	4.69
1668	In uncooked meat	(*a*)	(*a*)	(*a*)	(*a*)	59.70	6.50
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1665	In cooked meat	(*a*)	(*a*)	(*a*)	(*a*)	88.07	27.85
1665	In broth	(*a*)	(*a*)	(*a*)	(*a*)	11.93	72.15
1668	In broth on basis of total weight of uncooked meat	(*a*)	2.09	(*a*)	(*a*)	1.02	.67

a Determination lost.

Cooking Experiment No. 122.

In this experiment a very fat cut of beef flank was used. It was freed from all bone and visible gristle, but not from visible fat, cut into cubes of about 0.75 inch in size and thoroughly mixed. Two portions were taken—one (No. 1669) for cooking and the other (No. 1672) for analysis. In the cooking test the weighed meat was put into 2,000 cubic centimeters of vigorously boiling water, the temperature maintained as near the boiling point as possible for ten minutes, then allowed to drop to 85° C. and kept at this point until the total time of cooking equaled five hours.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams..	1,000.00
Weight of meat after cooking	do....	700.57
Loss in weight in cooking	do....	299.43
Loss in weight in cooking	per cent..	29.94

The detailed results of the experiment are shown in Tables 39 and 40.

Table 39.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 122.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1672	Beef, flank, uncooked	59.17	13.96	0.77	0.96	24.95	0.71	41.35	2.479
1669	Beef, flank, cooked	46.16	19.98	.04	.17	34.16	.24	54.59	3.210
1669	Broth (percent uncooked meat)		.70	.56	.71	6.18	.14	8.92	.292
	ON WATER-FREE BASIS.								
1672	Beef, flank, uncooked		34.19	1.89	2.35	61.11	1.74	101.28	6.071
1669	Beef, flank, cooked		37.32	.07	.32	63.80	45	101.96	5.996
1669	Broth (percent uncooked meat)		1.72	1.37	1.81	15.87	1.07	21.84	.715

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1672	Beef, flank, uncooked		1.21	0.77	0.96	0	0.55	3.49	0.440
1669	Beef, flank, cooked		.39	.04	.17	0	.20	.80	.077
1669	Broth (percent uncooked meat)		.61	.56	.74	0	.44	2.35	.278
	ON WATER-FREE BASIS.								
1672	Beef, flank, uncooked		2.99	1.89	2.35	0	1.35	8.58	1.078
1669	Beef, flank, cooked		.75	.07	.32	0	.37	1.51	.144
1669	Broth (percent uncooked meat)		1.50	1.37	1.81	0	1.07	5.75	.680

Table 39.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 122*—Continued.

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1672	Beef, flank, uncooked	....	12.75	0	0	24.95	0.16	37.86	2.039
1669	Beef, flank, cooked	....	19.59	0	0	34.16	.04	53.79	3.133
1669	Broth (percent uncooked meat)	....	.09	0	0	6.48	....	6.57	.014
	ON WATER-FREE BASIS.								
1672	Beef, flank, uncooked	....	31.20	0	0	61.11	.39	92.70	4.993
1669	Beef, flank, cooked	....	36.57	0	0	63.80	.08	100.45	5.852
1669	Broth (percent uncooked meat)	....	.22	0	0	15.87	....	16.09	.035

Table 40.—*Results of cooking (boiling) experiment No. 122.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1669	In cooked meat	325.48	139.97	0.28	1.19	239.31	1.68
1669	In broth	210.26	7.00	5.61	7.38	64.81	4.37
1672	In uncooked meat	535.74	146.97	5.89	8.57	304.12	6.05
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1669	In cooked meat	60.75	95.24	4.75	13.89	78.69	27.77
1669	In broth	39.25	4.76	95.25	86.11	21.31	72.23
1669	In broth on basis of total weight of uncooked meat	21.03	.70	.56	.74	6.48	.44

Cooking Experiment No. 123.

In this experiment very fat beef rump was cooked by the method followed in experiments Nos. 121 and 122. All the bone and gristle were removed from the meat and the entire cut was divided into pieces 0.5 to 0.75 inch thick and 0.75 to 1.25 inches long and thoroughly mixed. Three portions were then taken, two (Nos. 1673 and 1674) for cooking and one (No. 1676) for analysis in the uncooked condition. One portion (sample No. 1673) was plunged into 2,000 cubic centimeters of vigorously boiling water and kept at this temperature for ten minutes. The temperature was then allowed to drop to 85° C., at which point it was kept until the total time of cooking equaled five hours.

The losses in weight during cooking were as follows:

Weight of meat before cooking ....grams..	1,000.00
Weight of meat after cooking ....do....	643.20
Loss in weight in cooking ....do....	356.80
Loss in weight in cooking ....per cent..	35.68

Tables 41 and 42 give the detailed results of the experiment.

TABLE 41.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 123.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1676	Beef, rump, uncooked	52.26	13.69	0.66	0.88	32.38	0.74	48.35	2.400
1673	Beef, rump, cooked	38.35	19.31	.47	.43	42.03	.33	62.60	3.245
1673	Broth (percent uncooked meat)		.51	.61	.86	6.32	.50	8.80	.275
	ON WATER-FREE BASIS.								
1676	Beef, rump, uncooked		28.68	1.38	1.81	67.83	1.55	101.28	5.027
1673	Beef, rump, cooked		31.37	.76	.70	68.18	.54	101.55	5.264
1673	Broth (percent uncooked meat)		1.06	1.27	1.79	13.24	1.04	18.40	.576

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1676	Beef, rump, uncooked		1.54	0.66	0.88	0	0.61	3.69	0.456
1673	Beef, rump, cooked		.38	.17	.43	0	.25	1.53	.212
1673	Broth (percent uncooked meat)		.32	.61	.86	0	.50	2.29	.245
	ON WATER-FREE BASIS.								
1676	Beef, rump, uncooked		3.23	1.38	1.81	0	1.28	7.73	.955
1673	Beef, rump, cooked		.62	.76	.70	0	.41	2.49	.343
1673	Broth (percent uncooked meat)		.67	1.27	1.79	0	1.04	4.77	.514

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1676	Beef, rump, uncooked		12.15	0	0	32.38	0.13	44.66	1.944
1673	Beef, rump, cooked		18.96	0	0	42.03	.08	61.07	3.033
1673	Broth (percent uncooked meat)		.19	0	0	6.32	....	6.51	.030
	ON WATER-FREE BASIS.								
1676	Beef, rump, uncooked		25.45	0	0	67.83	0.27	93.55	4.072
1673	Beef, rump, cooked		30.75	0	0	68.18	.13	99.06	4.920
1673	Broth (percent uncooked meat)		.39	0	0	13.24	....	13.63	.062

TABLE 42.—*Results of cooking (boiling) experiment No. 123.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1673	In cooked meat	246.67	124.39	3.02	2.77	270.34	2.12
1673	In broth	268.97	5.06	6.05	8.55	63.20	4.97
1676	In uncooked meat	515.64	129.45	9.07	11.32	333.54	7.09
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1673	In cooked meat	47.84	96.09	33.30	24.47	81.05	29.90
1673	In broth	52.16	3.91	66.70	75.53	18.95	70.10
1673	In broth on basis of total weight of uncooked meat	26.90	.51	.61	.86	6.32	.50

COOKING EXPERIMENT No. 124.

For purposes of comparison a sample of beef rump (No. 1674) was pan broiled, the same cut being used as in the preceding test in which the meat was boiled. The thoroughly sampled beef was passed through a sausage mill three times, being carefully mixed each time, and then made up into cakes weighing 90 to 100 grams and pan broiled—that is, the meat was placed upon the surface of a moderately hot, dry, cast-iron pan and cooked for thirteen minutes, until fairly well done, the meat being turned frequently after it was well seared. No fat was added either before or during the cooking. When sufficiently cooked the meat was removed from the frying pan, care being taken to scrape off as much of the adhering material as possible, and then weighed.

The losses in weight during the cooking were as follows:

Weight of meat before cooking ....grams..	571.12
Weight of meat after cooking ....do....	368.47
Loss in weight in cooking...............................do....	202.65
Loss in weight in cooking ....per cent..	35.48

The results of the experiment are given in detail in Tables 43 and 44.

TABLE 43.—*Constituents of uncooked meats and cooked meats, soluble and insoluble in cold water, experiment No. 124.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1676	Beef, rump, uncooked.........	52.26	13.69	0.66	0.88	32.38	0.74	48.35	2.400
1674	Beef, rump, cooked	27.46	21.51	1.07	1.33	47.39	1.18	72.48	3.786
	ON WATER-FREE BASIS.								
1676	Beef, rump, uncooked.....................		28.68	1.38	1.84	67.83	1.55	101.28	5.027
1674	Beef, rump, cooked........................		29.65	1.48	1.83	65.33	1.63	99.92	5.218
	B. NUTRIENTS SOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1676	Beef, rump, uncooked.....................		1.54	0.66	0.88	0	0.61	3.69	0.456
1674	Beef, rump, cooked........................		.27	1.07	1.33	0	1.07	3.74	.387
	ON WATER-FREE BASIS.								
1676	Beef, rump, uncooked.....................		3.23	1.38	1.84	0	1.28	7.73	.955
1674	Beef, rump, cooked........................		.37	1.48	1.83	0	1.48	5.16	.534
	C. NUTRIENTS INSOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1676	Beef, rump, uncooked.....................		12.15	0	0	32.38	0.13	44.66	1.944
1674	Beef, rump, cooked........................		21.21	0	0	47.39	.11	68.74	3.399
	ON WATER-FREE BASIS.								
1676	Beef, rump, uncooked.....................		25.45	0	0	67.83	.27	93.55	4.072
1674	Beef, rump, cooked........................		29.28	0	0	65.33	.15	94.76	4.685

TABLE 44.—*Results of cooking (pan broiling) experiment No. 124.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1676	In uncooked meat	298.47	78.19	3.77	5.03	184.92	1.23
1674	In cooked meat	101.18	79.26	3.91	1.90	174.62	1.35
	Lost (−) or (apparently) gained (+)	−197.29	+1.07	.17	.13	−10.30	+.12
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1674	In cooked meat	33.90	100.00	100.00	97.12	94.43	100.00
	Lost (−) or (apparently) gained (+)	66.10	1.37	1.51	2.58	5.57	+2.81
	Lost (−) or (apparently) gained (+) in percentages of weight of uncooked meat.	−34.51	+.19	+.03	.02	−1.80	+.02

SERIES IX.—EXPERIMENTS NOS. 141-147.

This series of seven experiments was made to determine the influence of different methods of cooking (1) upon the soluble and insoluble constituents of meat, and (2) upon the nature and the quantities of nutrients lost. Lean beef round from which all bone, gristle, and most of the visible fat had been removed was used in the entire series, and was divided as follows: (1) A representative cross-section layer about one-half inch thick (sample No. 1764) was reserved for complete chemical analysis; (2) three steaks (samples Nos. 1765, 1766, and 1767), 1 inch thick, of approximately equal size and as similar as possible in appearance and composition were used in experiments Nos. 141, 142, and 143; (3) three pieces (samples Nos. 1768, 1770, and 1771), about 5 inches thick and 4 inches across and as similar as possible in appearance, shape, and size were taken for experiments Nos. 144, 146, and 147; and (4) one portion (No. 1769) was cut into 2-inch cubes for use in experiment No. 145.

EXPERIMENT NO. 141.

One of the steaks (sample No. 1765) 1 inch in thickness was sautéed. A small amount of beef fat (7.1 grams) was heated in the frying pan until it began to smoke, the meat then added and cooked for ten minutes with frequent turning. It was well browned but still underdone, or rare, and juicy.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	670.54
Weight of meat after cooking	do	566.40
Loss in weight in cooking	do	104.14
Loss in weight in cooking	per cent	15.53

The results are given in detail in Tables 45 and 46.

Table 45.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 141.*

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.								
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1764	Beef, round, uncooked	69.92	17.96	1.18	1.73	8.15	1.06	30.08	3.251
1765	Beef, round, cooked	64.02	22.51	1.38	1.69	9.88	1.18	36.64	4.044
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	59.71	3.92	5.75	27.09	3.52	99.99	10.808
1765	Beef, round, cooked	....	62.56	3.84	4.70	27.46	3.28	101.84	11.240
	B. NUTRIENTS SOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1764	Beef, round, uncooked	....	2.70	1.18	1.73	0	0.73	6.34	0.811
1765	Beef, round, cooked	....	1.03	1.38	1.69	0	.94	5.04	.608
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	9.00	3.92	5.75	0	2.44	21.11	2.695
1765	Beef, round, cooked	....	2.87	3.84	4.70	0	2.62	14.03	1.690
	C. NUTRIENTS INSOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1764	Beef, round, uncooked	....	15.26	0	0	8.15	0.33	23.74	2.440
1765	Beef, round, cooked	....	21.48	0	0	9.88	.24	31.60	3.436
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	50.71	0	0	27.09	1.08	78.88	8.113
1765	Beef, round, cooked	....	59.69	0	0	27.46	.66	87.81	9.550

Table 46.—*Results of cooking (sautéing) experiment No. 141.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1764	In uncooked meat	468.84	120.43	7.91	11.60	54.65	7.11
1765	In cooked meat	362.61	127.50	7.82	9.57	55.96	6.68
	Lost (−) or (apparently) gained (+)	−106.23	+7.07	− .09	− 2.03	+1.31	− .43
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1765	In cooked meat	77.34	100.00	98.86	82.50	100.00	93.95
	Lost (−) or (apparently) gained (+)	− 22.64	+5.87	−1.14	−17.50	+2.40	−6.05
	Lost (−) or (apparently) gained (+) in percentages of weight of uncooked meat.	− 15.84	+1.05	− .01	− .30	+ .20	− .06

Cooking Experiment No. 142.

For this experiment another one of the steaks (sample No. 1766) 1 inch in thickness was pan broiled as follows: After the pan had been heated until "blue hot," that is, until the iron has a bluish and characteristic appearance which housekeepers readily recognize, the meat was put in it and cooked for ten minutes, with frequent turning, no fat being added either before or during the cooking. The cooked meat was well browned on the outside, but decidedly underdone, or rare, and juicy within.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	673.91
Weight of meat after cooking	do	563.37
Loss in weight in cooking	do	110.54
Loss in weight in cooking	per cent	16.40

Tables 47 and 48 give the details of the experiment.

Table 47.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 142.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1764	Beef, round, uncooked	69.92	17.96	1.18	1.73	8.15	1.06	30.08	3.251
1766	Beef, round, cooked	65.61	22.31	1.46	1.72	8.18	1.19	34.86	4.037
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	59.71	3.92	5.75	27.09	3.52	99.99	10.808
1766	Beef, round, cooked	....	64.87	4.25	5.00	23.79	3.46	101.37	11.739

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1764	Beef, round, uncooked	....	2.70	1.18	1.73	0	0.73	6.34	0.811
1766	Beef, round, cooked	....	1.37	1.46	1.72	0	.99	5.54	.686
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	9.00	3.92	5.75	0	2.44	21.11	2.695
1766	Beef, round, cooked	....	3.98	4.25	5.00	0	2.88	16.11	1.996

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1764	Beef, round, uncooked	....	15.26	0	0	8.15	0.33	23.74	2.440
1766	Beef, round, cooked	....	20.94	0	0	8.18	.20	29.32	3.351
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	50.71	0	0	27.09	1.08	78.88	8.113
1766	Beef, round, cooked	....	60.89	0	0	23.79	.58	85.26	9.743

TABLE 48.—*Results of cooking (pan broiling) experiment No. 142.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams*
1764	In uncooked meat	471.20	121.03	7.95	11.66	54.92	7.14
1766	In cooked meat	369.63	125.69	8.23	9.69	46.08	6.70
	Lost (−) or (apparently) gained (+)	−101.57	+4.66	+ .28	− 1.97	− 8.84	− .44
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1766	In cooked meat	78.44	100.00	100.00	83.10	83.90	93.84
	Lost (−) or (apparently) gained (+)	−21.56	+3.85	+3.52	−16.90	−16.10	−6.16
	Lost (−) or (apparently) gained (+) in percentages of weight of uncooked meat	− 15.07	+ .69	+ .04	− .29	− 1.31	− .07

COOKING EXPERIMENT No. 143.

For this experiment the third 1-inch thick steak (sample No. 1767) was cooked by frying in deep fat. A quantity of lard sufficient to entirely cover the meat was heated to 200° C. and to this the meat was quickly added. The temperature dropped at once to 160° C. The cooking was continued for five minutes. The cooked meat was well browned on the edges, but decidedly underdone, or rare, and juicy in the interior.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	666.11
Weight of meat after cooking	do	471.08
Loss in weight in cooking	do	195.03
Loss in weight in cooking	per cent	29.28

Tables 49 and 50 show the detailed results of the experiment.

TABLE 49.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 143.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1764	Beef, round, uncooked	69.92	17.96	1.18	1.73	8.15	1.06	30.08	3.251
1767	Beef, round, cooked	57.78	27.59	1.62	1.83	10.42	1.43	42.89	4.934
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	59.71	3.92	5.75	27.09	3.52	99.99	10.808
1767	Beef, round, cooked	....	65.35	3.84	4.33	24.68	3.39	101.59	11.687

TABLE 49.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 143*—Continued.

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1764	Beef, round, uncooked		2.70	1.18	1.73	0	0.73	6.34	0.811
1767	Beef, round, cooked		.54	1.62	1.85	0	1.08	5.07	.605
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked		9.00	3.92	5.75	0	2.44	21.11	2.695
1767	Beef, round, cooked		1.26	3.81	4.38	0	2.56	12.01	1.433

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.								
1764	Beef, round, uncooked		15.26	0	0	8.15	0.33	23.74	2.440
1767	Beef, round, cooked		27.05	0	0	10.12	.65	37.82	1.329
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked		50.71	0	0	27.09	1.08	78.88	8.113
1767	Beef, round, cooked		61.09	0	0	21.68	.81	83.58	10.251

TABLE 50.—*Results of cooking (frying in lard) experiment No. 143.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1764	In uncooked meat	465.71	119.63	7.86	11.52	54.29	7.06
1767	In cooked meat	272.16	129.97	7.63	8.62	49.09	6.74
	Lost (−) or (apparently) gained (+)	−193.55	+10.34	− .23	−2.90	−5.20	− .32
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1767	In cooked meat	58.44	108.64	97.07	74.83	90.42	95.47
	Lost (−) or (apparently) gained (+)	−41.56	+ 8.64	−2.93	−25.17	−9.58	−4.53
	Lost (−) or (apparently) gained (+) in percentages of weight of uncooked meat.	−29.06	+ 1.55	− .03	− .44	− .78	− .05

COOKING EXPERIMENT NO. 144.

In this experiment one of the pieces of the beef round which was cut about 5 inches thick and 4 inches across (sample No. 1768) was plunged into 2,000 cubic centimeters of vigorously boiling water and the cooking continued at the boiling point for ten minutes, when the temperature was allowed to fall to 85° C., and maintained at this temperature until the total time of cooking was equal to three hours. The cooked meat was well done and quite dry. The volume of the final broth measured 1,740 cubic centimeters.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams..	1,027.72
Weight of meat after cooking	do...	639.87
Loss in weight in cooking	do....	387.85
Loss in weight in cooking	per cent..	37.74

The detailed results of the experiment are shown in Tables 51 and 52.

TABLE 51.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 144.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.								
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1764	Beef, round, uncooked	69.92	17.96	1.18	1.73	8.15	1.06	30.08	3.251
1768	Beef, round, cooked	58.81	31.19	.99	1.28	7.51	.89	41.86	5.309
1773	Broth (per cent uncooked meat)[a]	....	.20	.67	.73	.17	.46	2.23	.248
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	59.71	3.92	5.75	27.09	3.52	99.99	10.808
1768	Beef, round, cooked	....	75.72	2.40	3.11	18.23	2.16	101.62	12.889
1773	Broth (per cent uncooked meat)[a]	....	.67	2.24	2.44	.57	1.54	7.46	.823

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1764	Beef, round, uncooked	....	2.70	1.18	1.73	0	0.73	6.34	0.811
1768	Beef, round, cooked	....	.21	.99	1.28	0	.32	2.80	.352
1773	Broth (per cent uncooked meat)[a]	....	.15	.67	.73	0	.46	2.01	.239
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	9.00	3.92	5.75	0	2.44	21.11	2.695
1768	Beef, round, cooked	....	.51	2.40	3.11	0	.79	6.81	.855
1773	Broth (per cent uncooked meat)[a]	....	.48	2.24	2.44	0	1.53	6.69	.794

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1764	Beef, round, uncooked	....	15.26	0	0	8.15	0.33	23.74	2.440
1768	Beef, round, cooked	....	30.98	0	0	7.51	.57	39.06	4.957
1773	Broth (per cent uncooked meat)[a]	....	.05	0	0	.17	......	.22	.009
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	50.71	0	0	27.09	1.08	78.88	8.113
1768	Beef, round, cooked	....	75.21	0	0	18.23	1.37	94.81	12.034
1773	Broth (per cent uncooked meat)[a]	....	.19	0	0	.57	.01	.77	.029

[a] Broth from cooked meat No. 1768.

Table 52.—*Results of cooking (boiling) experiment No. 144.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1768	In cooked meat	376.31	199.58	6.33	8.19	48.05	5.69
1773	In broth	364.83	2.07	6.91	7.54	1.75	4.75
1764	In uncooked meat	741.14	201.65	13.24	15.73	49.80	10.44
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1768	In cooked meat	50.77	98.97	47.81	52.06	96.48	54.50
1773	In broth	49.23	1.03	52.19	47.94	3.52	45.50
1773	In broth on basis of total weight of uncooked meat	35.50	.20	.67	.73	.17	.46

Cooking Experiment No. 145.

In this experiment the beef round (sample No. 1769), in the form of 2-inch cubes, was plunged into 850 cubic centimeters of boiling water, the temperature of the water then reduced to 85° C. as quickly as possible, and the cooking continued at this temperature for three hours. The cooked meat was well done and quite dry. The volume of the final broth before dilution was 675 cubic centimeters.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	1,074.83
Weight of meat after cooking	do	587.28
Loss in weight in cooking	do	487.55
Loss in weight in cooking	per cent	45.36

Tables 53 and 54 give the details of the experiment.

Table 53.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 145.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous	Non-nitrogenous.				
	ON FRESH BASIS.								
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct*	*Per ct.*	*Per ct*	*Per ct.*
1764	Beef, round, uncooked	69.92	17.96	1.18	1.73	8.15	1.06	30.08	3.251
1769	Beef, round, cooked	56.49	34.41	.95	.88	6.87	.91	44.02	5.810
1772	Broth (per cent uncooked meat) *a*		.25	.75	.83	.44	.52	2.79	.280
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked		59.71	3.92	5.75	27.09	3.52	99.99	10.808
1769	Beef, round, cooked		79.09	2.18	2.02	15.79	2.09	101.17	13.353
1772	Broth (per cent uncooked meat) *a*		.82	2.50	2.77	1.45	1.73	9.27	.931

TABLE 53.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 145*—Continued.

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1764	Beef, round, uncooked		2.70	1.18	1.73	0	0.73	6.34	0.811
1769	Beef, round, cooked		.21	.95	.88	0	.63	2.67	.339
1772	Broth (per cent uncooked meat)[a]		.17	.75	.83	0	.52	2.27	.267
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked		9.00	3.92	5.75	0	2.41	21.11	2.695
1769	Beef, round, cooked		.50	2.18	2.02	0	1.46	6.16	.779
1772	Broth (per cent uncooked meat)[a]		.55	2.50	2.77	0	1.72	7.54	.888

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.								
1764	Beef, round, uncooked		15.26	0	0	8.15	0.33	23.71	2.440
1769	Beef, round, cooked		34.20	0	0	6.87	.28	41.35	5.471
1772	Broth (per cent uncooked meat)[a]		.08	0	0	.44	......	.52	.013
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked		50.71	0	0	27.09	1.08	78.88	8.113
1769	Beef, round, cooked		78.59	0	0	15.79	.63	95.01	12.571
1772	Broth (per cent uncooked meat)[a]		.27	0	0	1.45	.01	1.73	.043

[a] Broth from cooked meat No. 1769.

TABLE 54.—*Results of cooking (boiling) experiment No. 145.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1769	In cooked meat	331 75	202.08	5.58	5.17	40.35	5.34
1772	In broth	157.59	2.64	8.07	8.96	4.70	5.59
1764	In uncooked meat	789.34	204.72	13.65	14.13	45.05	10.93
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Percent.*
1769	In cooked meat	42.03	98.71	40.88	36.59	89.57	48.86
1772	In broth	57.97	1.29	59.12	63 41	10.43	51.14
1772	In broth on basis of total weight of uncooked meat	42.57	.25	.75	.83	.44	.52

COOKING EXPERIMENT No. 146.

In this experiment lean beef round (sample No. 1770), cut about 5 inches thick and 4 inches across, was cooked as a pot roast. A small amount of beef fat (9.3 grams) was heated in a flat-bottomed kettle until "smoking hot," when the meat was added and well browned on all sides. A small quantity of water was then added from time to time and the cooking continued for three hours, the pot being kept closely covered. The cooked meat was well done and medium dry.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	966.87
Weight of meat after cooking	do	545.08
Loss in weight in cooking	do	421.79
Loss in weight in cooking	per cent	43.62

The results of the experiment are given in detail in Tables 55 and 56.

TABLE 55.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 146.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1764	Beef, round, uncooked	69.92	17.96	1.18	1.73	8.15	1.06	30.08	3.251
1770	Beef, round, cooked	51.95	31.53	1.40	1.69	9.66	1.21	48.49	5.972
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	59.71	3.92	5.75	27.09	3.52	99.99	10.808
1770	Beef, round, cooked	....	71.86	2.91	3.52	20.10	2.52	100.91	12.429

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1764	Beef, round, uncooked	....	2.70	1.18	1.73	0	0.73	6.31	0.811
1770	Beef, round, cooked	....	.31	1.40	1.69	0	.81	4.21	.198
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	9.00	3.92	5.75	0	2.41	21.11	2.695
1770	Beef, round, cooked	....	.65	2.91	3.52	0	1.75	8.83	1.036

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1764	Beef, round, uncooked	....	15.26	0	0	8.15	0.33	23.71	2.110
1770	Beef, round, cooked	....	34.22	0	0	9.66	.37	44.25	5.474
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	50.71	0	0	27.09	1.08	78.88	8.113
1770	Beef, round, cooked	....	71.21	0	0	20.10	.77	92.08	11.393

TABLE 56.—*Results of cooking (pot roast) experiment No. 146.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams*	*Grams.*	*Grams.*	*Grams.*
1764	In uncooked meat	676.04	173.65	11.41	16.73	78.80	10.25
1770	In cooked meat	283.17	188.22	7.63	9.21	52.65	6.60
	Lost (−) or (apparently) gained (+)	−392.87	+14.57	− 3.78	− 7.52	−26.15	− 3.65
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1770	In cooked meat	41.89	100.00	66.87	55.05	66.80	64.39
	Lost (−) or (apparently) gained (+)	− 58.11	+ 8.39	−33.13	−44.95	−33.20	−35.61
	Lost (−) or (apparently) gained (+) in percentages of weight of uncooked meat.	− 40.63	+ 1.51	− .39	− .78	− 2.70	− .38

Cooking Experiment No. 147.

In this experiment, the last of the series, the lean beef round (sample No. 1771), cut about 5 inches thick and 4 inches across, was roasted. The weighed meat was placed on the rack in a roasting pan and put in the oven of a gas stove. The temperature for the first fifteen minutes was 249° C. and for the remaining forty-five minutes 193° C. The cooked meat was well browned, medium underdone, or rare, and quite juicy. The quantity of drippings obtained was very small.

The losses in weight in cooking were as follows:

Weight of meat before cooking	grams..	1, 104. 40
Weight of meat after cooking	do....	920. 92
Loss in weight in cooking	do....	183. 48
Loss in weight in cooking	per cent..	16. 61

Tables 57 and 58 show the detailed results of the experiment.

Table 57.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 147.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1764	Beef, round, uncooked	69. 92	17. 96	1. 18	1. 73	8. 15	1. 06	30. 08	3. 251
1771	Beef, round, cooked	64. 63	21. 45	1. 36	1. 55	9. 50	1. 17	35. 03	3. 870
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	59. 71	3. 92	5. 75	27. 09	3. 52	99. 99	10. 808
1771	Beef, round, cooked	....	60. 64	3. 84	4. 38	26. 86	3. 31	99. 03	10. 941

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1764	Beef, round, uncooked	....	2. 70	1. 18	1. 73	0	0. 73	6. 34	0. 811
1771	Beef, round, cooked	....	.75	1. 36	1. 55	0	.96	4. 62	.557
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	9. 00	3. 92	5. 75	0	2. 44	21. 11	2. 695
1771	Beef, round, cooked	....	2. 10	3. 84	4. 38	0	2. 71	13. 03	1. 574

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1764	Beef, round, uncooked	....	15. 26	0	0	8. 15	0. 33	23. 74	2. 440
1771	Beef, round, cooked	....	20. 70	0	0	9. 50	.21	30. 41	3. 313
	ON WATER-FREE BASIS.								
1764	Beef, round, uncooked	....	50. 71	0	0	27. 09	1. 08	78. 88	8. 113
1771	Beef, round, cooked	....	58. 51	0	0	26. 86	.60	86. 00	9. 367

TABLE 58.—*Results of cooking (roasting) experiment No. 147.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1764	In uncooked meat	772.20	198.35	13.03	19.11	90.01	11.71
1771	In cooked meat	595.19	197.54	12.52	14.27	87.49	10.77
	Lost (−) or (apparently) gained (+)	−177.01	−.81	−.51	−4.84	−2.52	−.94
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1771	In cooked meat	77.08	99.59	96.09	74.67	97.20	91.97
	Lost (−) or (apparently) gained (+)	−22.92	−.41	−3.91	−25.33	−2.80	−8.03
	Lost (−) or (apparently) gained (+) in percentages of weight of uncooked meat	−16.03	−.07	−.05	−.44	−.23	−.09

SERIES X.—EXPERIMENTS NOS. 150–156.

The object of this series of seven experiments was similar to that of Series IX, namely, to determine the influence of the different methods of cooking (1) upon the soluble and the insoluble constituents of meat and (2) upon the character and amounts of the losses of nutrients. The lean beef round selected was freed from all bone, gristle, and most of the visible fat and divided as follows: (1) A representative cross-section cut, about 0.5 inch thick (sample No. 1775), was reserved for analysis; (2) three steaks, 1 inch thick, of approximately equal size and as near alike as possible in appearance and composition, were cut for use in experiments Nos. 150, 151, and 152; (3) three pieces, about 5 inches thick and 4 inches across, as near alike in appearance, shape, and size as possible, were cut for experiments Nos. 153, 155, and 156; and (4) one portion was cut into pieces about 2 inches square for experiment No. 154.

COOKING EXPERIMENT NO. 150.

One of the steaks (No. 1776) 1 inch in thickness was sautéed. A small amount (12 grams) of beef fat was heated in a frying pan until it began to smoke. The meat was then added and cooked for twenty minutes, with frequent turning. When done it was well browned, underdone, or rare, and juicy.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	641.09
Weight of meat after cooking	do	549.85
Loss in weight in cooking	do	91.24
Loss in weight in cooking	per cent	14.23

The details of the experiment are shown in Tables 59 and 60.

TABLE 59.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 150.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1775	Beef, round, uncooked	73.28	18.67	1.13	1.40	4.91	1.09	27.20	3.349
1776	Beef, round, cooked	66.66	22.77	1.37	1.61	6.34	1.17	33.26	4.083
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked		69.87	4.23	5.24	18.38	4.08	101.80	12.534
1776	Beef, round, cooked		68.30	4.11	4.83	19.02	3.51	99.77	12.246

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1775	Beef, round, uncooked		2.20	1.13	1.40	0	0.87	5.60	0.714
1776	Beef, round, cooked		.73	1.37	1.61	0	.95	4.66	.556
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked		8.23	4.23	5.24	0	3.26	20.96	2.673
1776	Beef, round, cooked		2.19	4.11	4.83	0	2.85	13.98	1.667

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1775	Beef, round, uncooked		16.47	0	0	4.91	0.22	21.60	2.635
1776	Beef, round, cooked		22.04	0	0	6.34	.22	28.60	3.527
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked		61.64	0	0	18.38	.82	80.84	9.861
1776	Beef, round, cooked		66.11	0	0	19.02	.66	85.79	10.579

TABLE 60.—*Results of cooking (sautéing) experiment No. 150.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1775	In uncooked meat	469.79	119.69	7.24	8.98	31.48	6.99
1776	In cooked meat	366.53	125.20	7.53	8.85	34.86	6.43
	Lost (−) or (apparently) gained (+)	−103.26	+5.51	+ .29	− .13	+ 3.38	− .56
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent*	*Per cent*	*Per cent.*	*Per ct.*
1776	In cooked meat	78.02	100.00	100.00	98.55	100.00	91.99
	Lost (−) or (apparently) gained (+)	−21.98	+1.60	+4.01	−1.45	+10.74	−8.01
	Lost (−) or (apparently) gained (+) in percentage of weight of uncooked meat	−16.11	+ .86	+ .05	− .02	+ .53	− .09

COOKING EXPERIMENT NO. 151.

One of the steaks (sample No. 1777) 1 inch in thickness was pan-broiled as follows: The pan was heated until "blue hot" and the meat was then put in it and cooked for ten minutes with frequent turning, no fat being added either before or during the cooking. The cooked meat was well browned, decidedly underdone, or rare, and juicy.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	664.60
Weight of meat after cooking	do	536.05
Loss in weight in cooking	do	128.55
Loss in weight in cooking	per cent	19.34

Tables 61 and 62 give the details of the experiment.

TABLE 61.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 151.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1775	Beef, round, uncooked	73.28	18.67	1.13	1.40	4.91	1.09	27.20	3.349
1777	Beef, round, cooked	65.74	24.71	1.48	1.72	5.83	1.24	35.01	4.435
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked		69.87	4.23	5.24	18.38	4.08	101.80	12.534
1777	Beef, round, cooked		72.21	4.32	5.02	17.02	3.62	102.19	12.945

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1775	Beef, round, uncooked		2.20	1.13	1.40	0	0.87	5.60	0.714
1777	Beef, round, cooked		.58	1.48	1.72	0	1.05	4.83	.569
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked		8.23	4.23	5.24	0	3.26	20.96	2.673
1777	Beef, round, cooked		1.69	4.32	5.02	0	3.07	14.10	1.661

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1775	Beef, round, uncooked		16.47	0	0	4.91	0.22	21.60	2.635
1777	Beef, round, cooked		24.16	0	0	5.83	.19	30.18	3.866
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked		61.64	0	0	18.38	.82	80.84	9.861
1777	Beef, round, cooked		70.52	0	0	17.02	.55	88.09	11.284

TABLE 62.—*Results of cooking (pan broiling) experiment No. 151.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1775	In uncooked meat	487.02	124.08	7.51	9.30	32.63	7,24
1777	In cooked meat	352.40	132.62	7.93	9.22	31.25	6.65
	Lost (−) or (apparently) gained (+)	−134.62	+8.54	+ .42	− .08	−1.38	− .59
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1777	In cooked meat	72.36	100.00	100.00	99.14	95.77	91.85
	Lost (−) or (apparently) gained (+)	−27.64	+6.88	+5.59	− .86	−4.23	−8.15
	Lost (−) or (apparently) gained (+) in percentages of weight of uncooked meat	−20.26	+1.29	+ .06	− .01	− .21	− .09

COOKING EXPERIMENT NO. 152.

The third 1-inch steak (sample No. 1778) was cooked by "gas broiling," that is, broiling over a gas flame, for ten minutes, this method of cooking being substituted for frying in deep fat, the method used in the former series of experiments (experiment No. 143), to which the present series corresponds. The cooked meat was well browned, decidedly underdone, or rare, and juicy.

The losses in weight in cooking were as follows:

Weight of meat before cooking	grams	662.97
Weight of meat after cooking	do	551.95
Loss in weight in cooking	do	111.02
Loss in weight in cooking	per cent	16.75

Tables 63 and 64 give the details of the experiment.

TABLE 63.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 152.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1775	Beef, round, uncooked	73.28	18.67	1.13	1.40	4.91	1.09	27.20	3.349
1778	Beef, round, cooked	66.26	22.78	1.38	1.62	7.64	1.22	34.64	4.088
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked	....	69.87	4.23	5.24	18.38	4.08	101.80	12.534
1778	Beef, round, cooked	....	67.52	4.09	4.80	22.64	3.61	102.66	12.116

TABLE 63.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 152*—Continued.

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1775	Beef, round, uncooked		2.20	1.13	1.40	0	0.87	5.60	0.714
1778	Beef, round, cooked		.83	1.38	1.62	0	1.01	4.81	.575
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked		8.23	4.23	5.24	0	3.26	20.96	2.673
1778	Beef, round, cooked		2.46	4.09	4.80	0	2.99	14.34	1.704

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.								
1775	Beef, round, uncooked		16.47	0	0	4.91	0.22	21.60	2.635
1778	Beef, round, cooked		21.95	0	0	7.64	.21	29.80	3.513
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked		61.64	0	0	18.38	.82	80.84	9.861
1778	Beef, round, cooked		65.06	0	0	22.64	.62	88.32	10.412

TABLE 64.—*Results of cooking (gas broiling) experiment No. 152.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1775	In uncooked meat	485.82	123.78	7.49	9.28	32.55	7.23
1778	In cooked meat	365.72	125.73	7.62	8.94	42.17	6.73
	Lost (–) or (apparently) gained (+)	–120.10	+1.95	+ .13	– .34	+ 9.62	– .50
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1778	In cooked meat	75.28	100.00	100.00	96.34	100.00	93.08
	Lost (–) or (apparently) gained (+)	–24.72	+1.58	+1.74	–3.66	+29.55	–6.92
	Lost (–) or (apparently) gained (+) in percentages of weight of uncooked meat	–18.12	+ .29	+ .02	– .05	+ 1.45	– .08

COOKING EXPERIMENT No. 153.

One of the pieces of the beef round (sample No. 1779), about 5 inches thick and 4 inches across, was cooked by plunging it into 2,000 cubic centimeters of vigorously boiling water. This temperature was maintained for ten minutes, and then allowed to fall to 85° C. and kept at this point. The total time of cooking was three hours. The cooked meat was well done and quite dry.

The losses in weight in cooking were as follows:

Weight of meat before cooking	grams	1,098.31
Weight of meat after cooking	do	607.44
Loss in weight in cooking	do	490.87
Loss in weight in cooking	per cent	44.69

The details of the experiment are given in Tables 65 and 66.

TABLE 65.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 153.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1775	Beef, round, uncooked	73.28	18.67	1.13	1.40	4.91	1.09	27.20	3.349
1779	Beef, round, cooked	54.17	35.71	.94	1.04	7.88	.84	46.41	6.013
1784	Broth (per cent uncooked meat)[a]		.19	.73	.87	.38	.52	2.69	.295
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked		69.87	4.23	5.24	18.38	4.08	101.80	12.534
1779	Beef, round, cooked		77.92	2.05	2.27	17.19	1.83	101.26	13.120
1784	Broth (per cent uncooked meat)[a]		.69	2.75	3.27	1.56	1.93	10.20	.992
	B. NUTRIENTS SOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1775	Beef, round, uncooked		2.20	1.13	1.40	0	0.87	5.60	0.714
1779	Beef, round, cooked		.20	.94	1.04	0	.60	2.78	.332
1784	Broth (per cent uncooked meat)[a]		.16	.73	.87	0	.52	2.28	.261
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked		8.23	4.23	5.24	0	3.26	20.96	2.673
1779	Beef, round, cooked		.44	2.05	2.27	0	1.31	6.07	.724
1784	Broth (per cent uncooked meat)[a]		.61	2.75	3.27	0	1.93	8.56	.978
	C. NUTRIENTS INSOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1775	Beef, round, uncooked		16.47	0	0	4.91	0.22	21.60	2.635
1779	Beef, round, cooked		35.51	0	0	7.88	.24	43.63	5.681
1784	Broth (per cent uncooked meat)[a]		.03	0	0	.38		.41	.034
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked		61.64	0	0	18.38	.82	80.84	9.861
1779	Beef, round, cooked		77.48	0	0	17.19	.52	95.19	12.396
1784	Broth (per cent uncooked meat)[a]		.08	0	0	1.56		1.64	.014

[a] Broth from sample No. 1779.

TABLE 66.—*Results of cooking (boiling) experiment No. 153.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1779	In cooked meat	329.05	216.92	5.71	6.32	47.87	5.10
1784	In broth [a]	461.32	2.03	8.07	9.60	4.18	5.67
1775	In uncooked meat	790.37	218.95	13.78	15.92	52.05	10.77
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1779	In cooked meat	41.63	99.07	41.44	39.70	91.97	47.35
1784	In broth [a]	58.37	.93	58.56	60.30	8.03	52.65
1784	In broth on basis of total weight of uncooked meat [a]	42.00	.19	.73	.87	.38	.52

[a] Broth from sample No. 1779.

COOKING EXPERIMENT No. 154.

In this experiment, which is a duplicate of No. 145, the beef round cut into 2-inch cubes (sample No. 1780) was put into 850 cubic centimeters of boiling water. The temperature of the water was then allowed to drop to 85° C. and so maintained, the duration of the entire cooking period being three hours. The cooked meat was well done and dry.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams	1,052.17
Weight of meat after cooking	do	554.29
Loss in weight in cooking	do	497.88
Loss in weight in cooking	per cent	47.32

Tables 67 and 68 show the details of the experiment.

TABLE 67.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 154.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1775	Beef, round, uncooked	73.28	18.67	1.13	1.40	4.91	1.09	27.20	3.349
1780	Beef, round, cooked	55.19	36.15	.80	.92	6.62	.85	45.34	6.040
1783	Broth (per cent uncooked meat) [a]	....	.25	.73	.90	....	.53	....	.274
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked	....	69.87	4.23	5.24	18.38	4.08	101.80	12.534
1780	Beef, round, cooked	....	80.67	1.79	2.05	14.77	1.87	101.15	13.479
1783	Broth (per cent uncooked meat) [a]	....	.93	2.74	3.35	....	1.97	....	1.027

TABLE 67.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 154*—Continued.

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1775	Beef, round, uncooked	....	2.20	1.13	1.40	0	0.87	5.60	0.714
1780	Beef, round, cooked	....	.13	.80	.92	0	.57	2.42	.276
1783	Broth (per cent uncooked meat)[a]	....	.12	.73	.90	0	.53	2.28	.255
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked	....	8.23	4.23	5.24	0	3.26	20.96	2.673
1780	Beef, round, cooked	....	.29	1.79	2.05	0	1.27	5.40	.616
1783	Broth (per cent uncooked meat)[a]	....	.47	2.74	3.35	0	1.96	8.52	.953

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1775	Beef, round, uncooked	....	16.47	0	0	4.91	0.22	21.60	2.635
1780	Beef, round, cooked	....	36.02	0	0	6.62	.28	42.92	5.764
1783	Broth (per cent uncooked meat)[a]	....	.13	0	0	......	......	....	.019
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked	....	61.64	0	0	18.38	.82	80.84	9.861
1780	Beef, round, cooked	....	80.38	0	0	14.77	.60	95.75	12.863
1783	Broth (per cent uncooked meat)[a]	....	.46	0	0	......	......	....	.074

[a] Broth from sample No. 1780.

TABLE 68.—*Results of cooking (boiling) experiment No. 154.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1780	In cooked meat	305.91	200.38	4.43	5.10	36.69	4.71
1783	In broth[a]	....	2.62	7.70	9.42	....	5.53
1775	In uncooked meat	....	203.00	12.13	14.52	....	10.24
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1780	In cooked meat	....	98.71	36.52	35.12	....	46.00
1783	In broth[a]	....	1.29	63.48	64.88	....	54.00
1783	In broth on basis of total weight of uncooked meat[a]	....	.25	.73	.90	....	.53

[a] Broth from sample No. 1780.

COOKING EXPERIMENT NO. 155.

The second piece of lean beef round (sample No. 1781), cut about 5 inches thick and 4 inches across, was cooked as a pot roast. A small quantity of beef fat (9 grams) was heated in a flat-bottomed kettle until "smoking" hot, the meat added, and well browned on all sides. A small quantity of water was added from time to time and the cooking continued for three hours, the pot being kept closely covered. The cooked meat was well done and medium dry.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams..	1,041.33
Weight of meat after cooking	do....	558.56
Loss in weight in cooking	do....	482.77
Loss in weight in cooking,	per cent..	46.36

Tables 69 and 70 show the details of the experiment.

TABLE 69.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 155.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per. ct.*
1775	Beef, round, uncooked	73.28	18.67	1.13	1.40	1.91	1.09	27.20	3.349
1781	Beef, round, cooked	52.96	34.61	1.11	1.17	9.87	1.10	47 86	5.891
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked	....	69.87	4.23	5.24	18.38	4.08	101.80	12.534
1781	Beef, round, cooked	....	73.57	2.36	2.49	20.98	2.33	101.73	12.523

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1775	Beef, round, uncooked	....	2 20	1.13	1.40	0	0.87	5.60	0.714
1781	Beef, round, cooked	....	.42	1.11	1.17	0	.83	3.53	.421
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked	....	8.23	4.23	5.24	0	3.26	20.96	2.673
1781	Beef, round, cooked	....	.89	2.36	2.49	0	1.76	7.50	.895

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1775	Beef, round, uncooked	....	16.47	0	0	4.91	0.22	21.60	2.635
1781	Beef, round, cooked	....	34.19	0	0	9.87	.27	44.33	5.470
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked	....	61.64	0	0	18.38	.82	80.84	9.861
1781	Beef, round, cooked	....	72.68	0	0	20.98	.57	94.23	11.628

TABLE 70.—*Results of cooking (pot roasting) experiment No. 155.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1775	In uncooked meat	763.08	194.42	11.77	14.58	51.12	11.35
1781	In cooked meat	295.81	193.32	6.20	6.54	55.13	6.14
	Loss (–) or (apparent) gain (+)[a]	–467.27	–1.10	– 5.57	– 8.04	+4.01	– 5.21
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1781	In cooked meat	38.77	99.43	52.67	44.86	100.00	54.10
	Loss (–) or (apparent) gain (+)[a]	– 61.23	– .57	–47.33	–55.14	+7.84	–45.90
	Loss (–) or (apparent) gain (+) in percentages of weight of uncooked meat[a]	– 44.87	– .11	– .54	– .77	+ .39	– .49

[a] See U. S. Dept. Agr., Office of Experiment Stations Bul. 141, p. 62 et seq.

COOKING EXPERIMENT No. 156.

The third piece of the lean beef round (sample No. 1782), cut about 5 inches thick and 4 inches across, was cooked by roasting in the oven of a gas stove, the weighed meat being placed on the rack of a roasting pan. The temperature of the oven for the first fifteen minutes was 249° C. and for the remaining forty minutes of the cooking period 193° C. The cooked meat was well browned, decidedly underdone, or rare, and juicy.

The losses in weight in cooking were as follows:

Weight of meat before cooking	grams	1,110.88
Weight of meat after cooking	do	935.49
Loss in weight in cooking	do	175.39
Loss in weight in cooking	per cent	15.79

The details of the experiment are shown in Tables 71 and 72.

TABLE 71.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 156.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1775	Beef, round, uncooked	73.28	18.67	1.13	1.40	4.91	1.09	27.20	3.349
1782	Beef, round, cooked	68.58	23.19	.94	1.27	5.42	1.16	31.98	4.011
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked		69.87	4.23	5.24	18.38	4.08	101.80	12.534
1782	Beef, round, cooked		73.80	2.99	4.04	17.25	3.69	101.77	12.766

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1775	Beef, round, uncooked		2.20	1.13	1.40	0	0.87	5.60	0.714
1782	Beef, round, cooked		1.23	.94	1.27	0	.95	4.39	.497
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked		8.23	4.23	5.24	0	3.26	20.96	2.673
1782	Beef, round, cooked		3.91	2.99	4.04	0	3.02	13.96	1.582

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1775	Beef, round, uncooked		16.47	0	0	4.91	0.22	21.60	2.635
1782	Beef, round, cooked		21.96	0	0	5.42	.21	27.59	3.514
	ON WATER-FREE BASIS.								
1775	Beef, round, uncooked		61.64	0	0	18.38	.82	80.84	9.861
1782	Beef, round, cooked		69.89	0	0	17.25	.67	87.81	11.184

TABLE 72.—*Results of cooking (roasting) experiment No. 156.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1775	In uncooked meat	814.05	207.40	12.55	15.55	54.54	12.11
1782	In cooked meat	641.56	216.94	8.79	11.88	50.70	10.85
	Loss (−) or (apparent) gain (+)[a]	−172.49	+ 9.54	− 3.76	− 3.67	− 3.84	− 1.26
	Proportion of nutrients:	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1782	In cooked meat	78.81	100.00	70.04	76.40	92.96	89.60
	Loss (−) or (apparent) gain (+)[a]	− 21.19	+ 4.60	−29.96	−23.60	− 7.04	−10.40
	Loss (−) or (apparent) gain (+) in percentages of weight of uncooked meat[a].	− 15.53	+ .86	− .34	− .33	− .35	− .11

[a] See U. S. Dept. Agr., Office of Experiment Stations Bul. 141, p. 62 et seq.

MEATS COOKED BY DRY HEAT AND THEN BY BOILING.

SERIES XI.—EXPERIMENTS NOS. 133–136.

The chief object of this series of four experiments was to discover what influence the previous browning of meat has (1) upon the nature and quantity of the losses, and (2) upon the character of the resulting cooked meats. Lean beef round from which all bone, gristle, and lumps of visible fat had been removed was used in all the tests. The entire cut was divided into 2-inch cubes, and after thorough mixing was separated into five portions—four (Nos. 1743, 1744, 1745, and 1746) for cooking, and one (No. 1741) for complete chemical analysis.

COOKING EXPERIMENT NO. 133.

Sample No. 1743 was used for the first experiment, and was cooked by placing it first in 2,000 cubic centimeters of boiling water and then cooking at this temperature for three hours.

The losses in weights were as follows:

Weight of meat before cooking	grams..	1,000.00
Weight of meat after cooking	do....	548.22
Loss in weight in cooking	do....	451.78
Loss in weight in cooking	per cent..	45.18

The details of the experiment are given in Tables 73 and 74.

TABLE 73.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 133.*

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.								
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1741	Beef, round, uncooked	72.46	18.91	1.24	1.78	4.52	1.06	27.51	3.424
1743	Beef, round, cooked	57.65	34.92	.77	1.04	5.06	.74	42.53	5.834
1743	Broth (percent uncooked meat)	....	.39	.89	1.11	.46	.62	3.47	.347
	ON WATER-FREE BASIS.								
1741	Beef, round, uncooked	....	68.66	4.50	6.46	16.41	3.85	99.88	12.433
1743	Beef, round, cooked	....	82.45	1.82	2.46	11.95	1.75	100.43	13.776
1743	Broth (percent uncooked meat)	....	1.43	3.22	4.03	1.66	2.26	12.60	1.262
	B. NUTRIENTS SOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1741	Beef, round, uncooked	....	2.80	1.24	1.78	0	0.89	6.71	0.846
1748	Beef, round, cooked[a]	....	.33	.77	1.04	0	.57	2.71	.300
1743	Broth (percent uncooked meat)	....	.35	.89	1.11	0	.62	2.97	.340
	ON WATER-FREE BASIS.								
1741	Beef, round, uncooked	....	10.15	4.50	6.46	0	3.23	24.34	3.071
1748	Beef, round, cooked[a]	....	.78	1.82	2.46	0	1.35	6.41	.707
1743	Broth (percent uncooked meat)	....	1.27	3.22	4.03	0	2.25	10.77	1.236
	C. NUTRIENTS INSOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1741	Beef, round, uncooked	....	16 11	0	0	4.52	0 17	20.80	2.578
1748	Beef, round, cooked[a]	....	34.59	0	0	5.06	.17	39.82	5.534
1743	Broth (percent uncooked meat)	....	.04	0	0	.46	....	.50	.007
	ON WATER-FREE BASIS.								
1741	Beef, round, uncooked	....	58.51	0	0	16.41	.62	75.54	9.362
1748	Beef, round, cooked[a]	....	81.67	0	0	11.95	.40	94.02	13.069
1743	Broth (percent uncooked meat)	....	.16	0	0	1.66	.01	1.83	.026

[a] Cooked meat from sample No. 1743.

TABLE 74.—*Results of cooking (boiling) experiment No. 133.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1743	In cooked meat	316.05	191.44	4.22	5.70	27.74	4.06
1743	In broth	417.08	3.94	8.87	11.10	4.57	6.22
1741	In uncooked meat	733.13	195.38	13.09	16.80	32.31	10.28
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1743	In cooked meat	43.11	97.98	32.24	33.93	85.86	39.49
1743	In broth	56.89	2.02	67.76	66.07	14.14	60.51
1743	In broth on basis of total weight of uncooked meat	41.71	.39	.89	1.11	.46	.62

COOKING EXPERIMENT No. 134.

The second portion of beef round (sample No. 1744) was plunged into boiling water and the temperature of the water maintained as near the boiling point as possible for ten minutes. It was then allowed to drop to 85° C. and the cooking continued at this temperature until the total period covered three hours.

The losses in weight in cooking were as follows:

Weight of meat before cooking	grams..	1,000.00
Weight of meat after cooking	do....	543.07
Loss in weight in cooking	do....	456.93
Loss in weight in cooking	per cent..	45.69

Tables 75 and 76 record the details of the experiment.

TABLE 75.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No 134.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.								
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1741	Beef, round, uncooked	72.46	18.91	1.24	1.78	4.52	1.06	27.51	3.424
1744	Beef, round, cooked	57.88	35.05	.79	1.08	4.83	.73	42.48	5.862
1744	Broth (percent uncooked meat)	....	.33	.87	1.19	.31	.61	3.31	.331
	ON WATER-FREE BASIS.								
1741	Beef, round, uncooked	....	68.66	4.50	6.46	16.41	3.85	99.88	12.433
1744	Beef, round, cooked	....	83.21	1.88	2.56	11.47	1.73	100.85	13.917
1744	Broth (percent uncooked meat)	....	1.21	3.15	4.31	1.14	2.23	12.04	1.203

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1741	Beef, round, uncooked	....	2.80	1.24	1.78	0	0.89	6.71	0.846
1749	Beef, round, cooked[a]	....	.33	.79	1.08	0	.53	2.73	.307
1744	Broth (percent uncooked meat)	....	.28	.87	1.19	0	.61	2.95	.322
	ON WATER-FREE BASIS.								
1741	Beef, round, uncooked	....	10.15	4.50	6.46	0	3.23	24.34	3.071
1749	Beef, round, cooked[a]	....	.78	1.88	2.56	0	1.26	6.48	.728
1744	Broth (percent uncooked meat)	....	1.00	3.15	4.31	0	2.22	10.68	1.171

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1741	Beef, round, uncooked	....	16.11	0	0	4.52	0.17	20.80	2.578
1749	Beef, round, cooked[a]	....	34.72	0	0	4.83	.20	39.75	5.555
1744	Broth (percent uncooked meat)	....	.05	0	0	.31	....	.36	.009
	ON WATER-FREE BASIS.								
1741	Beef, round, uncooked	....	58.51	0	0	16.41	.62	75.54	9.362
1749	Beef, round, cooked[a]	....	82.43	0	0	11.47	.47	94.37	13.189
1744	Broth (percent uncooked meat)	....	.21	0	0	1.14	.01	1.36	.032

[a] Cooked meat from sample No. 1744.

TABLE 76.—*Results of cooking (boiling) experiment No. 134.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1744	In cooked meat	314.33	190.35	4.29	5.87	26.23	3.96
1744	In broth	423.80	3.32	8.68	11.86	3.13	6.14
1741	In uncooked meat	738.13	193.67	12.97	17.73	29.36	10.10
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1744	In cooked meat	42.58	98.29	33.08	33.11	89.34	39.21
1744	In broth	57.42	1.71	66.92	66.89	10.66	60.79
1744	In broth on basis of total weight of uncooked meat	42.38	.33	.87	1.19	.31	.61

COOKING EXPERIMENT NO. 135.

The third 1,000-gram portion (sample No. 1745) of the beef round, cut into 2-inch cubes, was first browned or sautéed in 26.3 grams of beef fat for fifteen minutes, and then while still hot was transferred to 2,000 cubic centimeters of boiling distilled water, part of which was first used to rinse out the frying pan. The pan was further cleaned by scraping with a spatula, and all material removed was added to the meat. The cooking was continued at the temperature of boiling water until the total time equaled three hours.

The losses in weight in cooking were as follows:

Weight of meat before cooking ....grams..	1,000.00
Weight of meat after cooking ....do....	560.68
Loss in weight in cooking....................do....	439.32
Loss in weight in cooking ....per cent..	43.93

The detailed results of the experiment are shown in tables 77 and 78.

TABLE 77.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 135.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1741	Beef, round, uncooked	72.46	18.91	1.24	1.78	4.52	1.06	27.51	3.424
1745	Beef, round, cooked	57.19	33.28	.72	.79	7.74	.73	43.26	5.556
1745	Broth (percent uncooked meat)	....	.43	.82	1.07	2.48	.57	5.37	.331
	ON WATER-FREE BASIS.								
1741	Beef, round, uncooked	....	68.66	4.50	6.46	16.41	3.85	99.88	12.433
1745	Beef, round, cooked	....	77.74	1.68	1.85	18.08	1.70	101.05	12.978
1745	Broth (percent uncooked meat)	....	1.56	2.98	3.87	9.00	2.07	19.48	1.203

Table 77.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 135*—Continued.

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1741	Beef, round, uncooked	....	2.80	1.24	1.78	0	0.89	6.71	0.816
1750	Beef, round, cooked[a]	....	.24	.72	.79	0	.51	2.26	.270
1745	Broth (percent uncooked meat)	....	.33	.82	1.07	0	.57	2.79	.316
	ON WATER-FREE BASIS.								
1741	Beef, round, uncooked	....	10.15	4.50	6.46	0	3.23	24.34	3.071
1750	Beef, round, cooked[a]	....	.57	1.68	1.85	0	1.19	5.29	.631
1745	Broth (percent uncooked meat)	....	1.20	2.98	3.87	0	2.06	10.11	1.146

C. NUTRIENTS INSOLUBLE IN COLD WATER.

	ON FRESH BASIS.								
1741	Beef, round, uncooked	....	16.11	0	0	4.52	0.17	20.80	2.578
1750	Beef, round, cooked[a]	....	33.04	0	0	7.74	.22	41.00	5.286
1745	Broth (percent uncooked meat)	....	.10	0	0	2.48	....	2.58	.015
	ON WATER-FREE BASIS.								
1741	Beef, round, uncooked	....	58.51	0	0	16.41	.62	75.54	9.362
1750	Beef, round, cooked[a]	....	77.17	0	0	18.08	.51	95.76	12.347
1745	Broth (percent uncooked meat)	....	.36	0	0	9.00	.01	9.37	.057

[a] Cooked meat from sample No. 1745.

Table 78.—*Results of cooking (browned in fat, then boiled) experiment No 135.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1745	In cooked meat	320.65	186.59	4.04	4.43	43.40	4.09
1745	In broth	385.69	4.29	8.19	10.66	21.79	5.70
1741	In uncooked meat	706.34	190.88	12.23	15.09	68.19	9.79
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1745	In cooked meat	45.40	97.75	33.03	29.36	63.65	41.78
1745	In broth	54.60	2.25	66.97	70.64	36.35	58.22
1745	In broth on basis of total weight of uncooked meat	38.57	.43	.82	1.07	2.48	.57

Cooking Experiment No. 136.

The fourth 1,000-gram portion of beef round (sample No. 1746), in the form of 2-inch cubes, was first browned or sautéed in 21 grams of beef fat for fifteen minutes, and while still hot was transferred to 2,000 cubic centimeters of boiling distilled water. The same precautions were used as in the preceding experiment to transfer the sautéed meat without loss from the frying pan to the vessel in which it was boiled. The meat was further cooked by maintaining the temperature of the water as near the boiling point as possible for ten minutes and then allowing it to drop to 85° C., keeping it at this point until the total time of cooking equaled three hours.

The losses in weight during cooking were as follows:

Weight of meat before cooking	grams..	1,000.00
Weight of meat after cooking	do....	557.76
Loss in weight in cooking	do....	442.24
Loss in weight in cooking	per cent..	44.22

Tables 79 and 80 give the details of the experiment.

TABLE 79.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 136.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1741	Beef, round, uncooked	72.46	18.91	1.24	1.78	4.52	1.06	27.51	3.424
1746	Beef, round, cooked	56.50	34.13	.73	.91	7.12	.70	43.59	5.696
1746	Broth (percent uncooked meat)	....	.35	.84	1.10	1.62	.61	4.52	.323
	ON WATER-FREE BASIS.								
1741	Beef, round, uncooked	....	68.66	4.50	6.46	16.41	3.85	99.88	12.433
1746	Beef, round, cooked	....	78.46	1.68	2.09	16.37	1.61	100.21	13.094
1746	Broth (percent uncooked meat)	....	1.25	3.03	3.98	5.88	2.20	16.34	1.172

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1741	Beef, round, uncooked	....	2.80	1.24	1.78	0	0.89	6.71	0.846
1751	Beef, round, cooked [a]	....	.15	.73	.91	0	.51	2.30	.260
1746	Broth (percent uncooked meat)	....	.21	.84	1.10	0	.61	2.76	.302
	ON WATER-FREE BASIS.								
1741	Beef, round, uncooked	....	10.15	4.50	6.46	0	3.23	24.34	3.071
1751	Beef, round, cooked [a]	....	.35	1.68	2.09	0	1.17	5.29	.597
1746	Broth (percent uncooked meat)	....	.77	3.03	3.98	0	2.19	9.97	1.096

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1741	Beef, round, uncooked	....	16.11	0	0	4.52	0.17	20.80	2.578
1751	Beef, round, cooked [a]	....	33.98	0	0	7.12	.19	41.29	5.436
1746	Broth (percent uncooked meat)	....	.14	0	0	1.62	....	1.76	.021
	ON WATER-FREE BASIS.								
1741	Beef, round, uncooked	....	58.51	0	0	16.41	.62	75.54	9.362
1751	Beef, round, cooked [a]	....	78.11	0	0	16.37	.44	94.92	12.497
1746	Broth (percent uncooked meat)	....	.48	0	0	5.88	.01	6.37	.076

[a] Cooked meat from sample No. 1746.

Table 80.—*Results of cooking (browned in fat, then cooked) experiment No. 136.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1746	In cooked meat	315.13	190.36	4.07	5.08	39.71	3.90
1746	In broth	397.26	3.45	8.35	10.95	16.18	6.05
1741	In uncooked meat	712.39	193.81	12.42	16.03	55.89	9.95
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1746	In cooked meat	44.24	98.22	32.77	31.69	71.05	39.20
1746	In broth	55.76	1.78	67.23	68.31	28.95	60.80
1746	In broth on basis of total weight of uncooked meat	39.73	.35	.84	1.10	1.62	.61

Series XII.—Experiments Nos. 137–140.

The chief object of this, as of the preceding series, was to study the influence of previous browning of meats (1) upon the nature and quantity of the losses and (2) upon the chemical composition and nutritive value of boiled meats. Lean beef round from which all bone, gristle, and lumps of visible fat had been removed, was cut into 2-inch cubes, thoroughly mixed, and divided into five portions, four (samples Nos. 1754 to 1757) for cooking and one (No. 1753) for analysis.

Cooking Experiment No. 137.

In this test the weighed beef (sample No. 1754) was placed in 2,000 cubic centimeters of cold water and the water gradually heated, the flame being so regulated that at the end of the first hour the temperature had reached 85° C. The cooking was continued at this temperature for three hours. The broth from the cooked meat before diluting equaled 1,890 cubic centimeters.

The losses in weight in cooking were as follows:

Weight of meat before cooking	grams	900.00
Weight of meat after cooking	do	481.82
Loss in weight in cooking	do	418.18
Loss in weight in cooking	per cent	46.46

The results of the experiment are shown in detail in Tables 81 and 82.

TABLE 81.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 137.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1753	Beef, round, uncooked	73.65	19.23	1.11	1.52	4.24	1.07	27.17	3.433
1754	Beef, round, cooked	56.24	35.21	.78	.82	6.80	.70	44.31	5.884
1754	Broth (percent uncooked meat)		.54	.86	1.06	.86	.60	3.92	.363
	ON WATER-FREE BASIS.								
1753	Beef, round, uncooked		72.98	4.21	5.77	16.09	4.06	103.11	13.028
1754	Beef, round, cooked		80.46	1.78	1.87	15.54	1.60	101.25	13.446
1754	Broth (percent uncooked meat)		2.05	3.27	4.01	3.28	2.27	14.88	1.377

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1753	Beef, round, uncooked		2.39	1.11	1.52	0	0.92	5.94	0.739
1758	Beef, round, cooked[a]		.20	.78	.82	0	.55	2.35	.282
1754	Broth (percent uncooked meat)		.17	.86	1.06	0	.59	2.68	.304
	ON WATER-FREE BASIS.								
1753	Beef, round, uncooked		9.09	4.21	5.77	0	3.47	22.54	2.805
1758	Beef, round, cooked[a]		.46	1.78	1.87	0	1.25	5.36	.645
1754	Broth (percent uncooked meat)		.66	3.27	4.01	0	2.25	10.19	1.153

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1753	Beef, round, uncooked		16.84	0	0	4.24	0.15	21.23	2.694
1758	Beef, round, cooked[a]		35.01	0	0	6.80	.15	41.96	5.602
1754	Broth (percent uncooked meat)		.37	0	0	.86	.01	1.24	.059
	ON WATER-FREE BASIS.								
1753	Beef, round, uncooked		63.89	0	0	16.09	.59	80.57	10.223
1758	Beef, round, cooked[a]		80.00	0	0	15.54	.35	95.89	12.801
1754	Broth (percent uncooked meat)		1.39	0	0	3.28	.02	4.69	.224

[a] Cooked meat from sample No. 1754.

TABLE 82.—*Results of cooking (boiling) experiment No 137.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1754	In cooked meat	270.98	169.65	3.76	3.95	32.76	3.37
1754	In broth	382.90	4.87	7.75	9.51	7.77	5.38
1753	In uncooked meat	653.88	174.52	11.51	13.46	40.53	8.75
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1754	In cooked meat	41.44	97.21	32.67	29.35	80.83	38.51
1754	In broth	58.56	2.79	67.33	70.65	19.17	61.49
1754	In broth on basis of total weight of uncooked meat	42.54	.54	.86	1.06	.86	.60

COOKING EXPERIMENT No. 138.

The second portion of beef round (sample No. 1755), cut into 2-inch cubes, was placed in 2,000 cubic centimeters of cold water, the temperature being in one hour gradually increased to the boiling point of water, and the cooking continued at this temperature for three hours. The broth from the cooked meat before diluting equaled 1,500 cubic centimeters.

The losses in weight in cooking were as follows:

Weight of meat before cooking	grams	900.00
Weight of meat after cooking	do	483.34
Loss in weight in cooking	do	416.66
Loss in weight in cooking	per cent	46.30

The detailed results of the experiment are shown in Tables 83 and 84.

TABLE 83.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 138.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1753	Beef, round, uncooked	73.65	19.23	1.11	1.52	4.24	1.07	27.17	3.433
1755	Beef, round, cooked	56.20	35.11	.74	.90	7.35	.71	41.81	5.857
1755	Broth (percent uncooked meat)	....	.57	.89	1.06	1.62	.63	4.77	.377
	ON WATER-FREE BASIS.								
1753	Beef, round, uncooked	....	72.98	4.21	5.77	16.09	4.06	103.11	13.028
1755	Beef, round, cooked	....	80.16	1.69	2.06	16.78	1.62	102.31	13.372
1755	Broth (percent uncooked meat)	....	2.18	3.38	4.03	6.13	2.40	18.12	1.431

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1753	Beef, round, uncooked	....	2.39	1.11	1.52	0	0.92	5.91	0.739
1759	Beef, round, cooked[a]	....	.44	.74	.90	0	.42	2.50	.309
1755	Broth (percent uncooked meat)	....	.26	.89	1.06	0	.63	2.84	.327
	ON WATER-FREE BASIS.								
1753	Beef, round, uncooked	....	9.09	4.21	5.77	0	3.47	22.54	2.805
1759	Beef, round, cooked[a]	....	1.00	1.69	2.06	0	.96	5.71	.706
1755	Broth (percent uncooked meat)	....	.98	3.38	4.03	0	2.40	10.79	1.240

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1753	Beef, round, uncooked	....	16.84	0	0	4.24	0.15	21.23	2.694
1759	Beef, round, cooked[a]	....	34.67	0	0	7.35	.29	42.31	5.548
1755	Broth (percent uncooked meat)	....	.31	0	0	1.62	....	1.93	.050
	ON WATER-FREE BASIS.								
1753	Beef, round, uncooked	....	63.89	0	0	16.09	.59	80.57	10.223
1759	Beef, round, cooked[a]	....	79.16	0	0	16.78	.66	96.60	12.666
1755	Broth (percent uncooked meat)	....	1.20	0	0	6.13	....	7.33	.191

[a] Cooked meat from sample No. 1755.

Table 84.—*Results of cooking (boiling) experiment No. 138.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1755	In cooked meat	271.64	169.70	3.58	4.35	35.53	3.43
1755	In broth	373.69	5.16	8.01	9.56	14.54	5.70
1753	In uncooked meat	645.33	174.86	11.59	13.91	50.07	9.13
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1755	In cooked meat	42.09	97.05	30.89	31.27	70.96	37.57
1755	In broth	57.91	2.95	69.11	68.73	29.04	62.43
1755	In broth on basis of total weight of uncooked meat	41.52	.57	.89	1.06	1.62	.63

Cooking Experiment No. 139.

The third weighed portion of the beef round (sample No. 1756), in the form of 2-inch cubes, was browned or sautéed in 6.5 grams of beef fat for five minutes, and while still hot it was transferred to 2,000 cubic centimeters of cold water, care being taken to include all the browned material from the frying pan. The water was then slowly heated, the temperature at the end of an hour being 85° C. The cooking was continued at this temperature for three hours. The volume of the broth from the cooked meat before diluting equaled 1,740 cubic centimeters.

The losses in weight in cooking were as follows:

Weight of meat before cooking	grams	900.00
Weight of meat after cooking	do	518.20
Loss in weight in cooking	do	381.80
Loss in weight in cooking	per cent	42.42

Tables 85 and 86 give the results of the experiment in detail.

Table 85.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 139.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1753	Beef, round, uncooked	73.65	19.23	1.11	1.52	4.24	1.07	27.17	3.433
1756	Beef, round, cooked	57.22	32.84	.75	.75	8.00	.67	43.01	5.495
1756	Broth (per cent uncooked meat)	....	.32	.87	1.06	.58	.61	3.44	.330
	ON WATER-FREE BASIS.								
1753	Beef, round, uncooked	....	72.98	4.21	5.77	16.09	4.06	103.11	13.028
1756	Beef, round, cooked	....	76.76	1.75	1.75	18.70	1.57	100.53	12.845
1756	Broth (per cent uncooked meat)	....	1.21	3.30	4.02	2.22	2.33	13.08	1.253

TABLE 85.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 139*—Continued.

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1753	Beef, round, uncooked	....	2.39	1.11	1.52	0	0.92	5.91	0.739
1760	Beef, round, cooked [a]	....	.17	.75	.75	0	.50	2.17	.268
1756	Broth (percent uncooked meat)	....	.17	.87	1.06	0	.61	2.71	.306
	ON WATER-FREE BASIS.								
1753	Beef, round, uncooked	....	9.09	4.21	5.77	0	3.47	22.54	2.805
1760	Beef, round, cooked [a]	....	.40	1.75	1.75	0	1.16	5.06	.626
1756	Broth (percent uncooked meat)	....	.65	3.30	4.02	0	2.32	10.29	1.163

C. NUTRIENTS INSOLUBLE IN COLD WATER.

	ON FRESH BASIS.								
1753	Beef, round, uncooked	....	16.84	0	0	4.21	0.15	21.23	2.694
1760	Beef, round, cooked [a]	....	32.67	0	0	8.00	.17	40.84	5.227
1756	Broth (percent uncooked meat)	....	.15	0	0	.58	......	.73	.024
	ON WATER-FREE BASIS.								
1753	Beef, round, uncooked	....	63.89	0	0	16.09	.59	80.57	10.223
1760	Beef, round, cooked [a]	....	76.36	0	0	18.70	.11	95.47	12.219
1756	Broth (percent uncooked meat)	....	.56	0	0	2.22	.01	2.79	.090

[a] Cooked meat from sample No. 1756.

TABLE 86.—*Results of cooking (browned in fat, then cooked) experiment No. 139.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1756	In cooked meat	296.51	170.18	3.89	3.89	41.16	3.47
1756	In broth	350.79	2.89	7.84	9.53	5.25	5.52
1753	In uncooked meat	647.30	173.05	11.73	13.42	46.71	8.99
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1756	In cooked meat	45.81	98.34	33.16	28.90	88.76	38.60
1756	In broth	54.19	1.66	66.84	71.10	11.24	61.40
1756	In broth on basis of total weight of uncooked meat	38.98	.32	.87	1.06	.58	.61

COOKING EXPERIMENT NO. 140.

The fourth weighed portion (sample No. 1757) of 2-inch cubes of beef round, was browned or sautéed in 7 grams of beef fat for five minutes, and then while hot it was transferred to 2,000 cubic centimeters of cold water, care being taken to include all browned material adhering to the frying pan. One hour was required to gradually increase the temperature to that of boiling water, and the cooking was continued at this temperature for three hours. The volume of the final broth before diluting equaled 1,260 cubic centimeters.

The losses in weight in cooking were as follows:

Weight of meat before cooking	grams	900.00
Weight of meat after cooking	do	495.72
Loss in weight in cooking	do	404.28
Loss in weight in cooking	per cent	44.92

The detailed results of the experiment are given in Tables 87 and 88.

TABLE 87.—*Constituents of uncooked meats, cooked meats, and broths, soluble and insoluble in cold water, experiment No. 140.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	ON FRESH BASIS.								
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1753	Beef, round, uncooked	73.65	19.23	1.11	1.52	4.24	1.07	27.17	3.433
1757	Beef, round, cooked	56.45	35.01	.79	.91	6.83	.70	44.24	5.855
1757	Broth (per cent uncooked meat)	....	.37	.89	1.08	.65	.64	3.63	.345
	ON WATER-FREE BASIS.								
1753	Beef, round, uncooked	....	72.98	4.21	5.77	16.09	4.06	103.11	13.028
1757	Beef, round, cooked	....	80.39	1.81	2.09	15.68	1.61	101.58	13.444
1757	Broth (per cent uncooked meat)	....	1.41	3.39	4.11	2.46	2.41	13.78	1.311

B. NUTRIENTS SOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1753	Beef, round, uncooked	....	2.39	1.11	1.52	0	0.92	5.94	0.739
1761	Beef, round, cooked [a]	....	.49	.79	.91	0	.52	2.71	.332
1757	Broth (per cent uncooked meat)	....	.25	.89	1.08	0	.63	2.85	.325
	ON WATER-FREE BASIS.								
1753	Beef, round, uncooked	....	9.09	4.21	5.77	0	3.47	22.54	2.805
1761	Beef, round, cooked [a]	....	1.13	1.81	2.09	0	1.20	6.23	.763
1757	Broth (per cent uncooked meat)	....	.93	3.39	4.11	0	2.40	10.83	1.235

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Nitrogenous.	Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
1753	Beef, round, uncooked	....	16.84	0	0	4.24	0.15	21.23	2.694
1761	Beef, round, cooked [a]	....	34.52	0	0	6.83	.18	41.53	5.523
1757	Broth (per cent uncooked meat)	....	.12	0	0	.65	.01	.78	.020
	ON WATER-FREE BASIS.								
1753	Beef, round, uncooked	....	63.89	0	0	16.09	.59	80.57	10.223
1761	Beef, round, cooked [a]	....	79.26	0	0	15.68	.41	95.35	12.681
1757	Broth (per cent uncooked meat)	....	.48	0	0	2.46	.01	2.95	.076

[a] Cooked meat from sample No. 1761.

TABLE 88.—*Results of cooking (browned in fat, then boiled) experiment No 140.*

Laboratory No.	Distribution of nutrients.	Water.	Proteid.	Organic extractives.		Fat.	Ash.
				Nitrogenous.	Non-nitrogenous.		
	Weight of nutrients:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1757	In cooked meat	279.83	173.55	3.92	4.51	33.86	3.47
1757	In broth	371.60	3.34	8.03	9.75	5.84	5.72
1753	In uncooked meat	651.43	176.89	11.95	11.26	39.70	9.19
	Proportion of nutrients:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1757	In cooked meat	42.96	98.11	32.80	31.63	85.29	37.76
1757	In broth	57.04	1.89	67.20	68.37	14.71	62.24
1757	In broth on basis of total weight of uncooked meat	41.29	.37	.89	1.08	.65	.64

MEATS COOKED BY BROILING—DIFFERENCE IN SURFACE AND INTERIOR OF SAMPLE.

SERIES XIII.—EXPERIMENT NO. 157.

The special objects of this experiment were (1) to determine if possible how the cooking of meat by broiling developed flavor, and (2) to find out the nature of the chemical changes resulting when meats are thus cooked. A steak 1.75 inches thick, the fourth cut taken from the sirloin from an animal said to be about two years old, was cooked by gas broiling for twenty minutes. When cold the cooked meat was freed from visible fat and divided into three portions as follows: The thin, browned, outer surface (sample No. 1687) was cut away with a sharp knife, as little as possible of the gray layer immediately underneath being removed with it. It had an agreeable meaty flavor, suggesting the savory odors given off from broiling or roasting meat, though it seemed rather dry. For the second sample (No. 1698) the gray layer, about one-fourth of an inch thick in depth, next the outer brown surface was removed. This sample had a more pronounced and pleasing flavor than sample No. 1687 or the inner portion, No. 1689. It seemed to have lost some of the uncooked taste of the interior portion and to have acquired a little of the savoriness of the outer browned surface.

The inner portion of the steak (sample No. 1689) which was left after removing the outer layers was decidedly underdone, or rare, and had a very pleasant, fresh, meaty flavor and odor, in these respects more nearly resembling uncooked meat than the outer or the middle layer. These three samples and a portion of the uncooked meat were analyzed.

The losses in weights during cooking were as follows:

Weight of meat before cooking	grams..	2,452.23
Weight of meat after cooking	do....	1,991.55
Loss in weight in cooking	do....	460.68
Loss in weight in cooking	per cent..	18.79

The results of the experiments are shown in detail in Table 89.

TABLE 89.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 157.*

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
				Nitrogenous.	Non-nitrogenous.				
	A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.								
	ON FRESH BASIS.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1685	Beef, sirloin, uncooked	60.39	16.07	0.84	1.39	20.89	1.11	40.30	2.840
1687	Beef, sirloin, cooked, browned surface	48.47	24.54	1.36	1.73	23.70	1.33	52.66	4.363
1688	Beef, material next browned surface	62.68	23.44	1.15	1.75	11.20	1.18	38.72	4.119
1689	Beef, inner portion	70.23	20.28	1.14	1.66	7.45	1.02	31.55	3.611
	ON WATER-FREE BASIS.								
1685	Beef, sirloin, uncooked		40.57	2.12	3.51	52.74	2.80	101.74	7.169
1687	Beef, sirloin, cooked, browned surface		47.62	2.64	3.36	45.99	2.58	102.19	8.467
1688	Beef, material next browned surface		62.81	3.08	4.69	30.01	3.16	103.75	11.037
1689	Beef, inner portion		68.12	3.83	5.58	25.03	3.43	105.99	12.129
	B. NUTRIENTS SOLUBLE IN COLD WATER.								
	ON FRESH BASIS.								
1685	Beef, sirloin, uncooked		1.81	0.84	1.39	0	0.77	4.81	0.559
1687	Beef, sirloin, cooked, browned surface		.52	1.36	1.73	0	1.04	4.65	.520
1688	Beef, material next browned surface		.72	1.15	1.75	0	1.04	4.66	.484
1689	Beef, inner portion		1.21	1.14	1.66	0	.92	4.93	.560
	ON WATER-FREE BASIS.								
1685	Beef, sirloin, uncooked		4.57	2.12	3.51	0	1.94	12.14	1.410
1687	Beef, sirloin, cooked, browned surface		1.01	2.64	3.36	0	2.02	9.03	1.009
1688	Beef, material next browned surface		1.93	3.08	4.69	0	2.79	12.49	1.297
1689	Beef, inner portion		4.06	3.83	5.58	0	3.09	16.56	1.880
	C. NUTRIENTS INSOLUBLE IN COLD WATER								
	ON FRESH BASIS.								
1685	Beef, sirloin, uncooked		14.26	0	0	20.89	0.34	35.49	2.281
1687	Beef, sirloin, cooked, browned surface		24.02	0	0	23.70	.29	48.01	3.843
1688	Beef, material next browned surface		22.72	0	0	11.20	.14	34.06	3.635
1689	Beef, inner portion		19.07	0	0	7.45	.10	26.62	3.051
	ON WATER-FREE BASIS.								
1685	Beef, sirloin, uncooked		36.00	0	0	52.74	.86	89.60	5.760
1687	Beef, sirloin, cooked, browned surface		46.61	0	0	45.99	.56	93.16	7.458
1688	Beef, material next browned surface		60.88	0	0	30.01	.37	91.26	9.740
1689	Beef, inner portion		64.06	0	0	25.03	.34	89.43	10.249

MEAT JUICE AND MEAT FIBER COOKED IN DIFFERENT WAYS.

SERIES XIV.—EXPERIMENTS NOS. 148, 149.

The object of this series was (1) to determine, if possible, whether it is the soluble or the insoluble constituents of meats which upon cooking are so changed as to produce the characteristic flavor of cooked meats, and (2) to learn whether or not the insoluble constituents of meat are made soluble by the process of cooking. No experiments of this nature have been thus far reported in connection with the nutrition investigations made in this laboratory. Fresh lean beef round, from which all bone, gristle, and visible fat were removed, was selected. The entire cut, weighing about 5 pounds, was divided into strips and then passed through a sausage mill four times, being mixed well after each grinding. A sample (No. 1677) of the thoroughly mixed meat was reserved for analysis, the results of which are given in the tables in connection with cooking experiment No. 149 (pp. 90–94).

The remainder of the finely divided meat was used for the preparation of meat juice and meat fiber, as follows: The entire quantity, about 4.5 pounds, was placed in a compound screw press, in portions weighing about 1.75 pounds each, and subjected to as much pressure as possible. About 700 cubic centimeters of meat juice were obtained. The meat fiber was now thoroughly moistened with cold distilled water (700 cubic centimeters), intimately mixed by kneading with the hands for thirty minutes, and again pressed, yielding about 800 cubic centimeters of liquid. The material remaining in the press was again moistened with water (700 cubic centimeters) and pressed, when about 900 cubic centimeters of liquid were recovered. The three quantities of liquid thus removed were combined, making 2,300 cubic centimeters in all, diluted with water to 2,500 cubic centimeters, thoroughly mixed, set aside, and designated sample No. 1678. The meat fiber left after pressing out the juice (sample No. 1679) was used for cooking experiment No. 149.

COOKING EXPERIMENT NO. 148.

The meat juice (sample No. 1678) was divided into six portions of 400 cubic centimeters each. One portion of the fresh juice was subjected to complete analysis in triplicate, the results obtained being given in Tables Nos. 90 and 91. The results have been calculated to show the amount of the different kinds of nitrogenous constituents and the total quantity of proximate constituents in 2,500 cubic centimeters of the meat juice.

TABLE 90.—*Weights in grams of the different forms of nitrogen in the 2,500 cubic centimeters of expressed beef juice, experiment No 148.*

Laboratory No.	In unfiltered juice.			In filtered juice.				
	Total nitrogen.	Insoluble nitrogen.	Soluble nitrogen.	Coagulated by heat.	Precipitated by $ZnSO_4$.	Proteid nitrogen.	Nonproteid nitrogen.	Precipitated by bromin directly.
	Grams.	*Gram.*	*Grams.*	*Grams.*	*Gram.*	*Grams.*	*Grams.*	*Grams.*
1678a	9.629	0.304	9.325	5.824	0.158	5.982	3.343	4.721
1678b	9.339	.326	9.013	5.889	.145	6.034	2.979	4.742
1678c	9.700	.350	9.350	5.891	.265	6.156	3.194	....
Average	9.556	.327	9.229	5.868	.189	6.057	3.172	4.732

TABLE 91.—*Weights in grams of the nutrients in the 2,500 cubic centimeters of expressed beef juice, experiment No. 148.*

Laboratory No.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.	Total nitrogen.
		Nitrogenous.	Nonnitrogenous.				
	Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1678a	39.288	10.430	16.845	0	11.156	77.719	9.629
1678b	39.750	9.294	17.394	0	10.531	76.969	9.339
1678c	40.663	9.965	15.331	0	10.812	76.781	9.700
Average	39.900	9.896	16.527	0	10.833	77.156	9.556

The second portion of the meat juice (sample No. 1678a) was placed on a water bath and heated gradually to 65° C. By the time the temperature had reached 52° C. a considerable amount of coagulated albumin had separated, and the liquid, while still retaining some of its original color, was beginning to turn brown. At 55° C. almost all the red color had disappeared and the liquid began to change to a grayish brown. At 65° C. the mixture had a very disagreeable alkaline taste, which "puckered" the tongue. No pleasant, meaty flavor could be detected. The temperature was maintained at 65° C. for one hour, but the continued cooking at this low temperature produced no noticeable change in flavor. For a comparison of the tastes of the coagulated cooked residue and the resulting clear filtrate, see the description of portion No. 1678c, page 89.

The third portion of meat juice (sample No. 1678b) was gradually heated upon the water bath until it reached a temperature of 85° C., and the cooking was continued at this temperature for one hour. Careful tests of the precipitate and the filtrate did not show any differences in taste or odor between this sample and No. 1678a or No. 1678c and No. 1678e, described below, cooked at about 100° C.

The fourth portion of meat juice (sample No. 1678c) was cooked with constant stirring for one hour at the temperature of boiling water upon an asbestos mat over a gas flame. The mixture was not noticeably different in taste from that obtained with sample No. 1678a. It was filtered to remove the coagulated material and washed thoroughly with hot water. The precipitate retained the characteristic strongly alkaline taste. The filtrate had only a slight alkaline taste and a very slight meaty flavor.

The fifth measured portion of meat juice (sample No. 1678d) was placed in an evaporating dish and carefully and slowly evaporated nearly to dryness on a hot plate, with constant stirring during the latter part of the process to prevent browning. Savory odors were given off before evaporation was complete and a thin coating of a reddish-brown material was noted on the side of the dish at the first level of the liquid. After evaporating almost to dryness the solid matter had some savory, meaty flavor, but the alkaline taste was still very strong. To prevent further browning of the savory products already formed the solid residue was transferred to a clean dish and heated at 130° C. for two hours. When thoroughly dried the material was pounded in a mortar to break up the hard lumps and permit uniform browning. The resulting product was a dark, reddish-brown, granular powder, having very little taste. A few grams added to hot water colored the water slightly and gave to the solution a very slight flavor. The alkaline taste still persisted, even in the brown coating produced on the side of the evaporating dish.

The sixth measured portion of meat juice (sample No. 1678e) was boiled for one hour and the coagulated and cooked proteid removed by filtration, the insoluble residue being thoroughly washed with hot water. Upon heating, a small additional quantity of coagulated albumin appeared in the filtrate. The liquid was reduced one-half in volume, again filtered, and the filtrate further evaporated. The concentrated solution had still a very slight alkaline taste, accompanied by a slight savory odor and pleasant flavor. The evaporation was very slowly and carefully continued, with constant stirring in such a way as to wash down the brownish colored substance formed on the side of the dish, and at the same time the sides of the dish were protected with asbestos paper to prevent any overbrowning. When evaporated until of a rich light-brown color and sirupy consistency, the liquid had a flavor very similar to that of commercial meat extract with the acid taste strongly emphasized. The browning was continued in an oven at 130° C. until the material had acquired a rich dark-brown color. Very little odor could be detected. The flavor seemed to be somewhat though not very greatly increased by the additional heating in the oven. A small amount of the material dissolved in water had a taste which closely resembled that of ordinary commercial beef extract of like dilution.

The precipitate obtained from sample No. 1678e, as described above, retained its strongly alkaline taste even after being well washed. It was placed in an evaporating dish and heated in an air oven at 130° C. for three hours. Both odor and taste were somewhat improved by this treatment, the alkaline taste seeming a little less strong and some savory odor being developed. The material was then further heated in an oven at 130° C. until it was thoroughly dry, and was then finely ground in a mortar to insure uniform browning and again heated. The final product was a dry, grayish-brown or black granular substance, with a very faint odor and practically tasteless. A few grams added to distilled water and boiled did not cause coloration of the water or yield any flavor.

Cooking Experiment No. 149.

In this experiment the residue (No. 1679) left after expressing and dissolving out the meat juice (see p. 87) was thoroughly mixed, passed twice through a sausage mill, again thoroughly mixed, and divided into seven approximately equal portions, which were used for the tests described below.

The first portion (sample No. 1679) was analyzed without further treatment, the results being given with the other details of the experiment in Tables 92, 93, and 94.

The second portion (sample No. 1679a), weighing 208.41 grams, was made into a ball, tied in cheese cloth, placed in a beaker containing 417 cubic centimeters of water at 65° C., and cooked at this temperature for three hours. During the cooking a rather faint odor somewhat resembling that of melted fat was noticeable. At the end of the cooking period the meat fiber was removed from the liquid and the flavor of each tested. The cooked meat fiber was rather light in color and had a very slight alkaline flavor which resembled that of the meat juice. The broth or liquid in which the extracted meat was cooked had a reddish-yellow tinge and very little flavor. The results of the analysis of the cooked meat and the broth are given in Tables 93 and 94.

The third portion of the extracted meat (sample No. 1679b), weighing 161.36 grams, was placed in a beaker containing twice its weight (322 grams) of boiling water, the temperature of the water reduced to 85° C., and the meat cooked at this temperature for three hours. During the cooking a faint but pleasant odor was given off. The cooked meat was darker in color than in the case of sample No. 1679a and had only a very slight flavor. The broth or liquid in which the extracted meat was cooked had a clear, light yellow color and a rather weak though pleasant flavor. The results of the analysis of the cooked meat and the broth are given in Tables 93 and 94.

The fourth portion of the extracted meat fiber (sample No. 1679c), weighing 162.55 grams, was placed in a beaker containing twice its weight (325 cubic centimeters) of boiling water and gently boiled for three hours. During the cooking a very pleasant and savory odor was noticeable. The cooked product was much darker in color than the other samples (Nos. 1679a and 1679b), and was very dry and somewhat difficult to masticate and swallow. The broth or liquid in which the extracted meat was cooked had a clear, bright yellow color and a decidedly better flavor than those from samples Nos. 1679a and 1679b. The results of the analysis of the cooked meat and the broth are given in Tables 93 and 94.

The fifth portion of the extracted meat fiber (sample No. 1679d), weighing 236.04 grams, was made into a small loaf and roasted in a gas oven at 193° C. for forty-five minutes. There was a thin, well-browned layer on the outside of the loaf, while the inside was rather moist and the fiber was soft and easy to masticate and swallow. The cooked material had a pleasant though faint meaty flavor, the outer crust being somewhat superior in these respects to the inside portion. The results of the chemical analysis of the cooked meat are given in Table 94.

The sixth portion of the extracted fiber (sample No. 1679e), weighing 206.4 grams, was made into a flat cake 1 inch in thickness, and broiled for twenty minutes over the flame of a gas broiler, each side of the cake being exposed to the direct flame for ten minutes. When cooked, the upper side of the cake was fairly well browned, and the lower side was browned in some places, while in others it was unchanged or only slightly yellowed. The cooked meat fiber was very dry and difficult to masticate and swallow and had only a slight flavor, although the outside layer had a somewhat more pronounced taste than the inside. The juice which exuded from the meat during the cooking was burned on the pan. Tables 92–94 summarize the data of the cooking tests.

TABLE 92.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 149.*

A. TOTAL NUTRIENTS IN ORIGINAL SUBSTANCE.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1677	Beef, round, raw	74.01	18.71	1.21	3.13	4.63	1.05	28.73	3.382
1679	Beef, round, extracted meat	77.61	17.77	.47	.96	4.35	.52	24.07	2.993
	ON WATER-FREE BASIS.								
1677	Beef, round, raw	....	71.99	4.66	12.04	17.81	4.04	110.54	13.013
1679	Beef, round, extracted meat	....	79.37	2.09	4.28	19.43	2.32	107.49	13.367

B. NUTRIENTS SOLUBLE IN COLD WATER.

	ON FRESH BASIS.								
1677	Beef, round, raw	....	2.44	1.21	3.13	0	0.84	7.62	0.779
1679	Beef, round, extracted meat	....	.66	.47	.96	0	.39	2.48	.256
	ON WATER-FREE BASIS.								
1677	Beef, round, raw	....	9.39	4.66	12.04	0	3.24	29.33	2.998
1679	Beef, round, extracted meat	....	2.95	2.09	4.28	0	1.74	11.06	1.142

Table 92.—*Constituents of uncooked meats and cooked meats soluble and insoluble in cold water, experiment No. 149*—Continued.

C. NUTRIENTS INSOLUBLE IN COLD WATER.

Laboratory No.	Kind of material.	Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.	Total solid matter.	Total nitrogen.
	ON FRESH BASIS.								
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1677	Beef, round, raw	....	16.27	0	0	4.63	0.21	21.11	2.603
1679	Beef, round, extracted meat	....	17.11	0	0	4.35	.13	21.59	2.737
	ON WATER-FREE BASIS.								
1677	Beef, round, raw	....	62.60	0	0	17.81	.80	81.21	10.014
1679	Beef, round, extracted meat	....	76.42	0	0	19.43	.58	96.43	12.225

Table 93.—*Results of cooking experiment No 149.*

Laboratory No.	Weight of meat taken.	Method of cooking. Amount of water taken.	Method of cooking. Temperature. At beginning.	Method of cooking. Temperature. During cooking.	Method of cooking. Duration of cooking.	Nutrients in broth expressed in percentage of fresh substance. Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Ash.	Total solid matter.	Total nitrogen.
	Grams.	*Cc.*	*°C.*	*°C.*	*Hours.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1679a	208.41	417	65	65	3	0.13	0.24	0.33	0.18	0.88	0.097
1679b	161.36	323	85	85	3	.10	.28	.37	.21	.96	.105
1679c	162.55	325	100	100	3	.22	.26	.33	.19	1.00	120

Table. 94.—*Results of the analysis of cold water extracts of meats used in cooking experiment No. 149.*

Laboratory No.	Kind of meat.	Water in fresh substance.	Method of cooking. Temperature. At beginning.	Method of cooking. Temperature. During cooking.	Method of cooking. Duration of cooking.
		Per cent.	*°C.*	*°C.*	*Hours.*
1677	Beef, round, unextracted, uncooked	74.01	....	....	....
1679	Beef, round, extracted, uncooked	77.61	....	....	....
1679a	Beef, round, extracted, boiled	66.50	65	65	3
1679b	Beef, round, extracted, boiled	61.17	85	85	3
1679c	Beef, round, extracted, boiled	61.77	100	100	3
1679d	Beef, round, extracted, roasted	65.70	193	193	$\frac{3}{4}$
1679e	Beef, round, extracted, gas broiled	53.87	....	....	$\frac{1}{3}$

Laboratory No.	Kind of meat.	Nutrients soluble in cold water expressed in percentage of fresh substance. Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Ash.	Total solid matter.	Total nitrogen.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1677	Beef, round, unextracted, uncooked	2.44	1.21	3.13	0.84	7.63	0.779
1679	Beef, round, extracted, uncooked	.66	.47	.39	.39	1.91	.256
1679a	Beef, round, extracted, boiled	.17	.38	.44	.26	1.25	.147
1679b	Beef, round, extracted, boiled	.13	.31	.36	.21	1.01	.121
1679c	Beef, round, extracted, boiled	.48	.34	.36	.19	1.37	.186
1679d	Beef, round, extracted, roasted	.29	.71	.99	.52	2.51	.273
1679e	Beef, round, extracted, gas broiled	.18	.86	1.12	.66	2.82	.305

TABLE 94.—*Results of the analysis of cold water extracts of meats used in cooking experiment No. 149*—Continued.

Laboratory No.	Kind of meat.	Nutrients soluble in cold water calculated to water-free basis.					
		Proteid.	Organic extractives.		Ash.	Total solid matter.	Total nitrogen.
			Nitrogenous.	Non-nitrogenous.			
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1677	Beef, round, unextracted, uncooked	9.31	4.66	12.01	3.23	29.27	2.997
1679	Beef, round, extracted, uncooked	2.95	2.10	1.74	1.74	8.53	1.143
1679a	Beef, round, extracted, boiled	.51	1.13	1.31	.78	3.73	.439
1679b	Beef, round, extracted, boiled	.34	.80	.93	.54	2.61	.312
1679c	Beef, round, extracted, boiled	1.26	.89	.94	.50	3.59	.487
1679d	Beef, round, extracted, roasted	.85	2.07	2.89	1.52	7.33	.796
1679e	Beef, round, extracted, gas broiled	.39	1.86	2.43	1.43	6.11	.661

The changes noted in these experiments may be briefly summarized as follows: When the juice is expressed from meat the fiber is grayish in color and the juice red; that is, the characteristic color of raw meat is due to coloring matters in solution. In cooking meat the coagulation of proteid existing in liquid form begins at 52° C. and continues as the temperature increases, the precipitation being practically complete at 100°. At 52° the red color of the meat juice begins to change to brown, the color changes becoming more pronounced as the temperature increases. At 65° an unpleasant alkaline flavor develops in the juice which is not modified by continued cooking at 65° to 100°. The flavor is more pronounced in the liquid portion of the meat juice than in the coagulated precipitate. At temperatures considerably over 100° and high enough to cause browning, savory flavors are developed which are much more pronounced in the liquid portion (extractives) than in the solid portion (proteid) of the meat juice, the flavor being very much like that of commercial meat extract. The fiber of the meat from which the juice is expressed had little distinctive flavor when cooked in different ways. Temperatures high enough to cause browning produced the most flavor.

These tests indicate that the changes produced in the juice or soluble part of meat by temperatures considerably over 100° are in a large measure responsible for the characteristic flavors of meat cooked by dry heat. In these tests fat was not studied, as the meat used was quite free from visible fat. Meat fats have a characteristic flavor which becomes more pronounced on cooking, and when the temperature is high enough to brown some of the fat the flavor is markedly increased. This browning or oxidation of fats and other bodies is of course due to their cleavage by heat. The nature of the chemical compounds formed has not been studied, so far as can be learned, with special reference to the fats, proteids, and extractives of flesh foods, though many studies of the oxidation products of typical fats, proteids, and other bodies have been reported. The collection and discussion of such material is an important matter, and studies with special reference to the bodies existing in fats are needed. From the investigations made in this laboratory and other available data, it seems fair to conclude that the flavors developed in the cooking of meat by the ordinary household methods are due very largely to the oxidation of extractive bodies in the meat juice and to the oxidation of fat.

BEEF BONES COOKED AS IN SOUP MAKING.

Series XV.—Experiments Nos. 127–130.

The four experiments included in this series were made with bones rather than meat in order to investigate the losses and changes which they sustain when cooked in hot water at different temperatures, as in ordinary household soup making.

In general the same methods were followed as in the tests in which meat was boiled, save that no attempt has as yet been made to analyze the bones before and after cooking. So far the amount and nature of the substances which bones yield when cooked in hot water have been determined entirely from the chemical composition of the resulting broths.

For the first two experiments (Nos. 127 and 128) beef rib bones, scraped to remove as much of the meat as possible, chopped into pieces from 0.5 to 1 inch in length, and thoroughly mixed, were divided into two portions, each weighing 1,000 grams. The first portion, for experiment No. 127, was placed in 2,000 cubic centimeters of vigorously boiling water and cooked for five hours. The resulting soup or broth was filtered and analyzed according to the methods described in an earlier section.

The second portion of bones (experiment No. 128) was cooked in 2,000 cubic centimeters of distilled water for ten minutes at the temperature of boiling water and for five hours at a considerably lower temperature, i. e., 84° or 85° C. The soup or broth was analyzed in the same way as the meat broths.

For the last two experiments of this series (Nos. 129 and 130) beef shank bones were scraped to remove as much of the meat as possible, sawed into pieces about 1.5 to 2 inches long, thoroughly mixed and divided into two portions weighing 1,000 grams each. The first portion (experiment No. 129) was placed in 2,000 cubic centimeters of vigorously boiling water and cooked at this temperature for five hours. The resulting broth was subjected to the usual treatment and analysis.

The second portion of shank bones (experiment No. 130) was cooked in 2,000 cubic centimeters of distilled water for ten minutes at the temperature of boiling water and for five hours at 84° to 85° C.

The results of these four experiments are given together in Tables 95 and 96.

TABLE 95.—*Results of cooking experiments Nos. 127–130.*

Cooking experiment No.	Laboratory No.	Kind of bones.	Weight before cooking.	Weight after cooking.	Loss (−) or gain (+) in weight in cooking.	Per cent loss (−) or gain (+) in cooking.
			Grams.	*Grams.*	*Grams.*	*Grams.*
127	1707	Rib	1,000.00	1,012.55	+ 12.55	+ 1.26
128	1708	Rib	1,000.00	1,029.35	+ 29.35	+ 2.91
129	1709	Shank	1,000.00	894.00	−106.00	−10.60
130	1710	Shank	1,000.00	871.52	−128.48	−12.85

TABLE 96.—*Composition of broths from cooking experiments Nos. 127–130.*

Experiment No.	Laboratory No.	Method of cooking.			Weight of nutrients in broths.					Nutrients in broths expressed in percentage of total weight of the uncooked bone.				
		Temperature.		Duration of cooking.	Proteid.	Organic extractives.		Fat.	Ash.	Proteid.	Organic extractives.		Fat.	Ash.
		At beginning.	During cooking.			Nitrogenous.	Nonnitrogenous.				Nitrogenous.	Nonnitrogenous.		
		° *C.*	° *C.*	*Hrs.*	*Grams*	*Grams*	*Grams*	*Grams.*	*Grs.*	*P. ct.*	*Per ct.*	*Per. ct.*	*Per ct.*	*P. ct.*
127	1707	100	100	5	14.61	1.40	6.61	20.16	1.20	1.46	0.14	0.66	2.02	0.12
128	1708	100	85	5	5.84	1.21	3.83	13.14	1.34	.58	.12	.38	1.31	.13
129	1709	100	100	5	1.25	.83	1.48	75.63	.57	.13	.08	.15	7.56	.06
130	1710	100	85	5	2.49	1.30	1.69	126.56	1.08	.25	.13	.17	12.66	.11

In experiments 127 and 128 with rib bones the percentages of nutrients, in terms of the total weight of the uncooked bone, were as follows: Proteid 1.02, nitrogenous extractives 0.13, nonnitrogenous extractives 0.52, fat 1.68, and ash 0.13. In experiments 129 and 130, in which shank bones were used, the corresponding percentages of nutrients were: Proteid 0.19, nitrogenous extractives 0.11, nonnitrogenous extractives 0.16, fat 10.11, and ash 0.09. From these results it appears that the nutritive matter other than fat obtained from the small, spongy rib bones is greater than that from the larger and more compact shank bones. The shank bones, however, are generally preferred for soup making, possibly because of a certain flavor imparted by the marrow, which is so abundant. Aside from the fat content, the amount of nutrients in bones is small, and it is evident, therefore, that the bones contribute very little to the value of the broth.

DISCUSSION OF RESULTS.

In studies of the composition of food comparatively few analyses of flesh have previously been reported in which the proteid nitrogen has been differentiated from the nonproteid nitrogen, and so far as the writers are aware none have been reported which indicate the total amount of nonnitrogenous extractives, though considerable work has been published regarding the amount of glycogen and other carbohydrates of meat. In most cases the total nitrogen directly determined is all reported as from proteid substances. In some cases, however, the proteids are subdivided into albumin, gelatinoids, and insoluble proteid. If space allowed it would be interesting in this connection to describe the pioneer work of Berzelius, Liebig, Moleschott, Schlossberger, and Bibra on the chemistry of flesh. It is hoped that time and opportunity may in the future be afforded for a thorough résumé of their researches.

COMPOSITION OF UNCOOKED MEATS.

The limited amount of work on such lines is shown by the fact that König,[a] who devotes 70 pages to the chemical analyses of various kinds of fresh meats in his extended compilation of data on the composition of food, refers to only three investigations in which an attempt has been made to distinguish between proteid and nonproteid nitrogen.

One of these investigations made by W. Henneberg, E. Kern, and H. Wattenberg[b] reports the analyses of 7 different cuts of mutton from each of two animals in which the combined extractives, the soluble proteids, the nonproteid organic extractives, and the ash are given. The method used by these investigators and others cited will be briefly referred to in connection with the discussion of the cold-water extracts of meat (p. 122). At present it suffices to say that Henneberg, Kern, and Wattenberg found that on the average fresh, fat-free mutton flesh had the following composition: Water 79.22 per cent, insoluble proteids 15.79 per cent, and total soluble matter 5 per cent, including albumin 1.61 per cent, nonproteid organic extractives 2.18 per cent, and ash 1.21 per cent. Almen[c] reported analyses of 13 different sorts of fish, albumin, organic nonproteid extractives, and proteids soluble in hot water (gelatinoids) being determined. It will be of interest to state that Almen obtained as an average of the above analyses of fish the following results: Water 64.24 per cent, albumin 2.09 per cent, extractives 2.56 per cent, gelatinoids 2.55 per cent, insoluble proteids 12.10 per cent, total nitrogenous matter 19.31 per cent, fat 9.44 per cent, and ash 7.34 per cent.

A study of the extractives of flesh was made by W. O. Atwater[d] and associates in the course of an extended investigation of the chemical composition and economic values of fish and invertebrates used for food. In the case of 30 specimens of fish, the albumin, the organic nonproteid extractives, the proteids soluble in hot water (gelatinoids), and the insoluble proteids were determined. As an average of the analyses of 24 samples of the edible portion of the flesh of fresh fish they obtained the following results: Water 75.52 per cent, albumin 1.55 per cent, extractives 1.95 per cent, gelatinoids 2.85 per cent, insoluble proteid 11.60 per cent, fat 5.13 per cent, and ash 1.33 per cent. The analyses of the edible portion of 7 samples of cured fish gave them the following average results: Water 50.53 per cent, albumin 0.61 per cent, extractives 3.66 per cent, gelatinoids 3.01 per cent, insoluble proteid 15.86 per cent, fat 9.75 per cent, and ash 15.87 per cent.

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[a] Chemie der menschlichen Nahrungs- und Genussmittel. 4 ed., I, p. 185.

[b] Jour. Landw., 26 (1878), p. 549.

[c] Analyse des Fleisches einiger Fische. Upsala, 1877.

[d] Amer. Chem. Jour., 9 (1887), p. 421. Ber. Deut. Chem. Gesell., 16 (1883), p. 1839.

An extended study of the chemical composition of the carcasses of 8 pigs was made by H. W. Wiley, with the collaboration of E. E. Ewell, W. H. Krug, T. C. Trescot, and others.[a] The carcasses were divided into 11 parts or cuts, and proteids insoluble in hot water, gelatinoids, and flesh bases, together with other constituents, were determined in air-dried samples of each cut. The average composition of the 8 pigs, expressed in percentages of the entire dressed animals, was as follows: Water, 36.43; fat, 49.67; proteids insoluble in water, 8.12; gelatinoids, 1.10; flesh bases, 1.14; total nitrogenous substances, 10.46; lecithin, 0.023; ash, 2.11; total, 98.90.

Mention must also be made of the work of Gautier,[b] who reported a very complete analysis of fresh mutton (neck and shoulder) and fresh beefsteak. Unfortunately, in spite of considerable effort, we have been unable to learn much regarding the methods followed by this investigator. His results will be considered in detail below in connection with the discussion of the cold-water extracts of meat. For purposes of comparison we have taken the liberty of putting Gautier's analytical results in approximately the same form as those mentioned above. The data are: For fresh beefsteak—water, 74.75 per cent; insoluble proteids, 15.50 per cent; coagulable proteid, 3.06 per cent; nonproteid organic extractives, 3.59 per cent; fat, 1.97 per cent, and ash, 1.09 per cent; and for fresh mutton—water, 74.92 per cent; insoluble proteids, 13.66 per cent; coagulable proteids soluble in cold water, 3.32 per cent; nonproteid organic extractives, 2.22 per cent; fats, 5.32 per cent, and ash, 1.25 per cent.

Offer and Rosenquist[c] studied the proportions of total nitrogen, nitrogen of extractives, and nitrogen of meat bases in fish and different kinds of raw, cooked, and preserved meat, in connection with an investigation of the comparative value of white and red meat in invalid dietetics. This work is referred to in more detail elsewhere (p. 142).

From a comparison of the data referred to above and those included in the present bulletin it seems fair to conclude that the modified methods of analysis of meat which have been used in the investigation here reported give considerably more knowledge regarding the chemical composition of meats than has been gained by these earlier analyses. Furthermore, they make it possible to compare in detail the chemical composition of the same meats before and after cooking, so that information regarding the chemical changes which occur in the different processes of cooking has thus been obtained. The methods which have been used in this work are referred to in some detail on preceding pages (p. 12) and have been more fully described in another publication.[a] The methods have been very thoroughly tested, and the authors are convinced that they give as accurate and reliable results as the methods commonly used for the analysis of foods, if, indeed, they do not surpass them.

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[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 53.

[b] Rev. Hyg. et Pol. Sanit., 19 (1897), p. 394.

[c] Berlin. Klin. Wchnschr., 36 (1899), pp. 937, 968, 1086.

For the sake of a more ready comparison of the results here obtained and those of a number of the previous investigations described above, a table summarizing such data is given herewith:

Table 97.—*Summary of analyses showing forms of proteids and the organic extractives of meat.*

Kind of meat.	Number of analyses.	Water.	Proteid.			Organic extractives.			Fat.	Ash.
			Insoluble.	Soluble.	Total.	Nitrogenous.	Non nitrogenous.	Total.		
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Mutton (fresh), Henneberg and associates..	11	79.22	15.79	1.61	17.40	....	....	2.18	0	1.21
Fish (fresh), Atwater and associates	24	75.52	14.45	1.55	16.00	....	....	1.95	5.13	1.33
Fish (cured), Atwater and associates	7	50.53	18.87	.61	19.48	....	....	3.66	9.75	15.87
Fish (fresh), Almen ...	8	73.14	13.16	2.48	15.64	....	....	1.93	8.48	1.40
Fish (salted), Almen ..	5	50.01	17.06	1.46	18.52	....	....	3.56	10.97	16.86
Pork (fresh air-dried), Wiley and associates.	88	36.43	9.22	....	9.22	1.14	....	....	49.67	2.11
Beef (fresh), Gautier ..	1	74.75	15.50	3.06	18.56	....	....	3.59	1.97	1.09
Mutton (fresh), Gautier.	1	74.92	13.66	3.32	16.98	....	....	2.22	5.32	1.25
Beef (fresh), Grindley and associates........	12	69.13	15.52	2.29	17.81	1.08	1.62	2.70	10.95	1.03
Veal (fresh), Grindley and associates........	2	75.75	16.23	2.37	18.60	1.17	1.66	2.83	2.48	1.13

The data presented in the above table show that fresh flesh from beef, veal, pork, mutton, and fish contains from 1.55 per cent to 3.32 per cent of soluble proteid matter coagulable by heat. The results obtained by the different investigators agree quite closely.

There has been no attempt, except in the first of the investigations here reported, to distinguish between the nitrogenous and the nonnitrogenous organic extractives. The results summarized indicate, however, that fresh flesh from the various sources given above contains from 1.93 per cent to 3.59 per cent of total organic extractives. It must be remembered in this connection that the methods used in determining the extractives by the different investigators mentioned above are not similar, and this may, in part, account for the slight variations which appear.

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[a] Jour. Amer. Chem. Soc., 27 (1905), p. 658.

The following tables (Nos. 98 and 99) give the analyses of all the uncooked meats used in connection with the cooking experiments here reported, the kinds and cuts of meat being plainly indicated. In each case figures are given for the composition of the fresh substance and for the same material calculated to a water-free basis:

TABLE 98.—*Chemical composition of uncooked meats (fresh substance).*

Laboratory No.	Cooking experiment No.	Kind of meat.	Water.	Proteid. Insoluble.	Proteid. Soluble.	Proteid. Total.	Organic extractives. Nitrogenous.	Organic extractives. Nonnitrogenous.	Organic extractives. Total.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1672	122	Beef, flank	59.17	12.75	1.21	13.96	0.77	0.96	1.73
1668	121	Beef, neck	71.29	15.45	2.30	17.75	.81	1.63	2.44
1637	107	Beef, round	75.53	16.25	2.76	19.01	1.08	2.22	3.30
1640	108–109	.....do	74.04	16.86	2.77	19.63	1.37	1.72	3.09
1647	110–113	.....do	74.18	16.29	1.82	18.11	1.41	1.95	3.36
1722	131–132	.....do	72.57	16.26	2.70	18.96	1.12	1.99	3.11
1741	133–136	.....do	72.46	16.11	2.80	18.91	1.24	1.78	3.02
1753	137–140	.....do	73.65	16.84	2.39	19.23	1.11	1.52	2.63
1761	141–147	.....do	69.92	15.26	2.70	17.96	1.18	1.73	2.91
1775	150–156	.....do	73.28	16.47	2.20	18.67	1.13	1.40	2.53
		Average Nos. 1637, 1640, 1647, 1722, 1741, 1753, 1761, and 1775	73.20	16.29	2.52	18.81	1.21	1.79	3.00
1676	123–124	Beef, rump	52.26	12.15	1.54	13.69	.66	.88	1.54
1705	125–126	.....do	61.22	......	......	[a]17.71	......	......	......
		Average for all beef	69.13	15.52	2.29	17.81	1.08	1.62	2.70
1656	114–116	Veal, leg	75.97	16.34	2.83	19.17	1.26	1.94	3.20
1662	117–120	.....do	75.53	16.12	1.90	18.02	1.08	1.37	2.15
		Average Nos. 1656 and 1662	75.75	16.23	2.37	18.60	1.17	1.66	2.83

Laboratory No.	Cooking experiment No.	Kind of meat.	Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Nonproteid nitrogen.	Ratio of nonproteid to proteid nitrogen.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
1672	122	Beef, flank	24.95	0.71	100.52	2.479	2.233	0.246	1: 9.1
1668	121	Beef, neck	8.77	1.02	101.27	3.098	2.840	.258	1:11.0
1637	107	Beef, round	......	1.19	......	3.390	3.042	.348	1: 8.7
1640	108–109	.....do	3.19	1.18	101.13	3.580	3.140	.440	1: 7.1
1647	110–113	.....do	4.28	1.28	101.21	3.350	2.898	.452	1: 6.4
1722	131–132	.....do	4.78	1.09	100.51	3.392	3.033	.359	1: 8.4
1741	133–136	.....do	4.52	1.06	99.97	3.424	3.026	.398	1: 7.6
1753	137–140	.....do	4.24	1.07	100.82	3.433	3.077	.356	1: 8.6
1764	141–147	.....do	8.15	1.06	100.00	3.251	2.873	.378	1: 7.6
1775	150–156	.....do	4.91	1.09	100.48	3.349	2.987	.362	1: 8.3
		Average Nos. 1637, 1640, 1647, 1722, 1741, 1753, 1761, and 1775	4.87	1.13	100.59	3.396	3.009	.387	1: 8.0
1676	123–124	Beef, rump	32.38	.74	100.61	2.400	2.190	.210	1:10.4
1705	125–126	.....do	20.23	.91	[a]100.07	[a]2.834	......	......	......
		Average for all beef	10.95	1.03	100.65	3.195	2.849	.346	1: 8.3
1656	114–116	Veal, leg	.96	1.15	100.45	3.470	3.067	.403	1: 7.6
1662	117–120	.....do	3.99	1.10	101.09	3.230	2.883	.347	1: 8.3
		Average Nos. 1656 and 1662	2.48	1.13	100.77	3.350	2.975	.375	1: 8.0

[a] Not included in the average.

TABLE 99.—*Chemical composition of uncooked meats (water-free basis).*

Laboratory No.	Cooking experiment No.	Kind of meat.	Proteid.			Organic extractives.		
			Insoluble.	Soluble.	Total.	Nitrogenous.	Non-nitrogenous.	Total.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1672	122	Beef, flank	31.20	2.99	34.19	1.89	2.35	4.24
1668	121	Beef, neck	53.81	8.02	61.83	2.82	5.68	8.50
1637	107	Beef, round	66.41	11.27	77.68	4.41	9.07	13.48
1640	108–109	....do	64.94	10.68	75.62	5.28	6.62	11.90
1647	110–113	....do	63.09	7.05	70.14	5.46	7.55	13.01
1722	131–132	....do	59.26	9.86	69.12	4.08	7.25	11.33
1741	133–136	....do	58.51	10.15	68.66	4.50	6.46	10.96
1753	137–140	....do	63.89	9.09	72.98	4.21	5.77	9.98
1764	141–147	....do	50.71	9.00	59.71	3.92	5.75	9.67
1775	150–156	....do	61.64	8.23	69.87	4.23	5.24	9.47
		Average Nos. 1637, 1640, 1647, 1722, 1741, 1753, 1764, and 1775	61.05	9.42	70.47	4.51	6.71	11.22
1676	123–124	Beef, rump	25.45	3.23	28.68	1.38	1.84	3.22
1705	125–126	....do	....	....	[a]45.69	....	....	....
		Average of all beef	54.45	8.14	62.59	3.83	5.78	9.61
1656	114–116	Veal, leg	67.99	11.78	79.77	5.24	8.07	13.31
1662	117–120	....do	65.88	7.76	73.64	4.41	5.60	10.01
		Average Nos. 1656 and 1662	66.94	9.77	76.71	4.83	6.84	11.67

Laboratory No.	Cooking experiment No.	Kind of meat.	Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Non-proteid nitrogen.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1672	122	Beef, flank	61.11	1.74	101.28	6.071	5.469	0.602
1668	121	Beef, neck	30.55	3.55	104.43	10.791	9.892	.899
1637	107	Beef, round	....	4.86	....	13.854	12.431	1.423
1640	108–109	....do	12.29	4.55	104.36	13.791	12.099	1.692
1647	110–113	....do	16.58	4.96	104.69	12.979	11.222	1.757
1722	131–132	....do	17.43	3.97	101.85	12.366	11.059	1.307
1741	133–136	....do	16.41	3.85	99.88	12.433	10.986	1.447
1753	137–140	....do	16.09	4.06	103.11	13.028	11.677	1.351
1764	141–147	....do	27.09	3.52	99.99	10.808	9.554	1.254
1775	150–156	....do	18.38	4.08	101.80	12.534	11.179	1.355
		Average Nos. 1637, 1640, 1647, 1722, 1741, 1753, 1764, and 1775	17.75	4.23	102.25	12.724	11.276	1.448
1676	123–124	Beef, rump	67.83	1.55	101.28	5.027	4.589	.438
1705	125–126	....do	[a]52.16	2.35	[a]100.20	[a]7.308	....	....
		Average of all beef	28.38	3.59	102.27	11.244	10.014	1.230
1656	114–116	Veal, leg	3.99	4.79	101.86	14.440	12.763	1.677
1662	117–120	....do	16.31	4.50	104.46	13.200	11.782	1.418
		Average Nos. 1656 and 1662	10.15	4.65	103.16	13.820	12.273	1.547

[a] Not included in the average.

These analyses apparently teach us nothing essentially new regarding the water, fat, and ash contents of meat, but they do increase our knowledge of the nitrogen-free organic extractives and the nitrogenous constituents, including both the proteid and the nitrogenous organic extractives.

By referring to Table 98, page 99, it will be seen that the average results here obtained for 12 samples of fresh beef flesh were as follows: Water 69.13 per cent, insoluble proteid 15.52 per cent, soluble proteid 2.29 per cent, total proteid 17.81 per cent, nitrogenous organic extractives 1.08 per cent, nonnitrogenous organic extractives 1.62 per cent, total organic extractives 2.70 per cent, fat 10.95 per cent, and ash 1.03 per cent. The average amount of nitrogen in different forms for the same samples was: Total nitrogen 3.195 per cent, proteid nitrogen 2.849 per cent, and nonproteid nitrogen 0.346 per cent. The ratio of the nonproteid to proteid nitrogen was 1:8.3. The average results obtained in the analysis of 2 samples of fresh veal were: Water 75.75 per cent, insoluble proteid 16.23 per cent, soluble proteid 2.37 per cent, total proteid 18.60 per cent, nitrogenous organic extractives 1.17 per cent, nonnitrogenous organic extractives 1.66 per cent, total organic extractives 2.83 per cent, fat 2.48 per cent, and ash 1.13 per cent. The average values for nitrogen were: Total nitrogen 3.350 per cent, proteid nitrogen 2.975 per cent, and nonproteid nitrogen, 0.375 per cent. The ratio of the nonproteid to proteid nitrogen was 1:8.

It will be seen that the soluble proteid in uncooked meat forms, approximately, 12.80 per cent, or about one-eighth, of the total proteid. The nonnitrogenous extractives are in all cases somewhat more abundant than are the nitrogenous extractives. In general, the soluble albumin and the nitrogenous and nonnitrogenous extractives vary inversely with the fat; that is to say, the meats which contain the most fat have, as a rule, the lower percentage of soluble albumin and organic extractives, and vice versa. However, the amount of extractives in corresponding cuts of meat from different animals may vary considerably even when the fat content is about the same. For example, lean beef round (sample No. 1775), containing 4.91 per cent of fat, has only 2.53 per cent of organic extractives, while lean beef round (sample No. 1647) contains 4.28 per cent of fat and has 3.36 of organic extractives.

The usual method of calculating the percentage of proteid in meats by multiplying the total nitrogen by the factor 6.25 evidently gives a much higher figure for the true proteids than should be assigned to them. For example, if the average total nitrogen (3.195 per cent) found in the twelve samples of fresh beef is multiplied by the factor 6.25, the product obtained is 19.97 per cent. The proteid obtained by actual analysis with the methods used in this investigation is only 17.81 per cent, or a difference of 2.16 per cent. The discrepancy is due to the fact that the former value includes organic extractives. Since the nutritive value of the organic extractives is certainly much less than that of the proteids, the usual method must necessarily lead to errors in the determination of the nutritive value of meats and meat products.

COMPOSITION OF MEATS COOKED BY BOILING.

So little work having to do with the influence of cooking upon the composition of meats has been found that it seems unnecessary to take it into consideration in discussing the results presented in connection with the present investigation.

The following tables (Nos. 100 and 101) summarize the data regarding the composition of the boiled meat, that is, meat cooked in hot water, this method of cooking being, as before explained, for convenience designated boiling, whatever the temperature of the water. The results are calculated, as before, to the fresh and to the water-free basis:

TABLE 100.—*Chemical composition of meats cooked by boiling (fresh substance).*

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Water.	Proteid.		
				At beginning.	During cooking.			Insoluble.	Soluble.	Total.
				°C.	*°C.*	*Hrs.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1642	1640	109	Beef, round	Cold.	85	3	59.91	35.07	0.13	35.20
1754	1753	137	do	Cold.	85	3	56.24	35.01	.20	35.21
			Average				58.08	35.04	.17	35.21
1756	1753	139	Beef, round (browned)	Cold.	85	3	57.22	32.67	.17	32.84
			Average Nos. 1642, 1754, and 1756				57.79	34.25	.17	34.42
1746	1741	136	Beef, round (browned)	85	85	3	56.50	33.98	.15	34.13
1769	1764	145	Beef, round	85	85	3	56.49	34.20	.21	34.41
1780	1775	154	do	85	85	3	55.19	36.02	.13	36.15
			Average Nos. 1769 and 1780				55.84	35.11	.17	35.28
			Average Nos. 1746, 1769, and 1780				56.06	34.74	.16	34.90
1641	1640	108	Beef, round	100	85	3	59.01	35.89	.38	36.27
1744	1741	134	do	100	85	3	57.88	34.72	.33	35.05
1768	1764	144	do	100	85	3	58.81	30.98	.21	31.19
1779	1775	153	do	100	85	3	54.17	35.51	.20	35.71
			Average				57.47	34.28	.28	34.56
1755	1753	138	Beef, round	Cold.	100	3	56.20	34.67	.44	35.11
1757	1753	140	Beef, round (browned)	Cold.	100	3	56.45	34.52	.49	35.01
			Average				56.33	34.59	.47	35.06
1743	1741	133	Beef, round	100	100	3	57.65	34.59	.33	34.92
1745	1741	135	Beef, round (browned)	100	100	3	57.19	33.04	.24	33.28
			Average				57.42	33.81	.29	34.10
			Average of all cooked 3 hours				57.07	34.35	.26	34.61
1646	1647	113	Beef, round	Cold.	65	5	62.93	31.89	.27	32.16
1645	1647	112	do	Cold.	85	5	59.84	32.87	.36	33.23
1654	1656	116	Veal, leg	Cold.	85	5	68.59	30.50	.60	31.10
1658	1662	118	do	Cold.	85	5	64.66	28.82	.31	29.13
			Average Nos. 1654 and 1658				66.63	29.66	.46	30.12
			Average Nos. 1645, 1654, and 1658				64.36	30.73	.42	31.15

TABLE 100.—*Chemical composition of meats cooked by boiling (fresh substance)*—Cont'd.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Water.	Proteid.		
				At beginning.	During cooking.			Insoluble.	Soluble.	Total.
				°C.	°C.	*Hrs.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1644	1647	111	Beef, round	100	85	5	59.12	33.85	0.29	31.14
1720	1722	131	do	100	85	5	55.31	31.72	.16	31.88
			Average				57.22	32.78	.23	33.01
1665	1668	121	Beef, neck	100	85	5	54.40	30.67	.19	30.86
1673	1676	123	Beef, rump	100	85	5	38.35	18.96	.38	19.34
1703	1705	125	do	100	85	5	48.34	26.75	.38	27.13
			Average Nos. 1673 and 1703				43.35	22.86	.38	23.24
1669	1672	122	Beef, flank	100	85	5	46.46	19.59	.39	19.98
1653	1656	115	Veal, leg	100	85	5	66.65	31.62	.49	32.11
1664	1662	117	do	100	85	5	61.87	29.21	.32	29.53
			Average Nos. 1653 and 1664				64.26	30.41	.41	30.82
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720				53.82	27.80	.33	28.12
1639	1637	107	Beef, round	100	100	5	59.68	33.32	.97	34.29
1643	1647	110	do	100	100	5	60.52	31.76	.92	32.68
1721	1722	132	do	100	100	5	57.12	31.42	.56	31.98
			Average				59.11	32.16	.82	32.98
1704	1705	126	Beef, rump	100	100	5	55.01	26.68	.90	27.58
1652	1656	114	Veal, leg	100	100	5	61.73	30.51	.44	30.95
			Average Nos. 1639, 1643, 1652, 1704, and 1721				59.41	30.73	.76	31.49
			Average of all cooked 5 hours				57.86	29.41	.47	29.88
			Average of all cooked 3 and 5 hours				57.50	31.57	.38	31.95

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Organic extractives.			Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Nonproteid nitrogen.	Ratio of nonproteid to proteid nitrogen.
				Nitrogenous.	Nonnitrogenous.	Total.							
				P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
1642	1640	109	Beef, round	0.43	0.56	0.99	3.93	0.51	100.54	5.770	5.632	0.138	1:40.8
1754	1753	137	do	.78	.82	1.60	6.80	.70	100.55	5.884	5.634	.250	1:22.5
			Average	.61	.69	1.30	5.37	.61	100.55	5.827	5.633	.194	1:31.7
1756	1753	139	Beef, round (browned)	.75	.75	1.50	8.00	.67	100.23	5.495	5.255	.240	1:21.9
			Average Nos. 1642, 1754, and 1756	.65	.71	1.36	6.24	.63	100.44	5.716	5.507	.209	1:26.3
1746	1741	136	Beef, round (browned)	.73	.91	1.64	7.12	.70	100.09	5.696	5.461	.235	1:23.2
1769	1764	145	Beef, round	.95	.88	1.83	6.87	.91	100.51	5.810	5.505	.305	1:18.0
1780	1775	154	do	.80	.92	1.72	6.62	.85	100.53	6.040	5.784	.256	1:22.6
			Average Nos. 1769 and 178	.88	.90	1.78	6.75	.88	100.52	5.925	5.645	.280	1:20.3
			Average Nos. 1746, 1769, and 1780	.83	.90	1.73	6.87	.82	100.38	5.849	5.583	.266	1:21.0

Table 100.—*Chemical composition of meats cooked by boiling (fresh substance)*—Cont'd.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Organic extractives.			Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Nonproteid nitrogen.	Ratio of nonproteid to proteid nitrogen.
				Nitrogenous.	Nonnitrogenous.	Total.							
				P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
1641	1640	108	Beef, round	0.33	0.45	0.78	4.38	0.50	100.94	5.910	5.803	0.107	1:54.2
1744	1741	134	.....do	.79	1.08	1.87	4.83	.73	100.36	5.862	5.608	.254	1:22.1
1768	1764	144	.....do	.99	1.28	2.27	7.51	.89	100.67	5.309	4.991	.318	1:15.7
1779	1775	153	.....do	.94	1.04	1.98	7.88	.84	100.58	6.013	5.713	.300	1:19.0
			Average	.76	.96	1.72	6.15	.74	100.64	5.774	5.529	.245	1:22.6
1755	1753	138	Beef, round	.74	.90	1.64	7.35	.71	101.01	5.857	5.618	.239	1:23.5
1757	1753	140	Beef, round (browned)	.79	.91	1.70	6.83	.70	100.69	5.855	5.602	.253	1:22.1
			Average	.77	.91	1.67	7.09	.71	100.85	5.856	5.610	.246	1:22.8
1743	1741	133	Beef, round	.77	1.04	1.81	5.06	.74	100.18	5.834	5.587	.247	1:22.6
1745	1741	135	Beef, round (browned)	.72	.79	1.51	7.74	.73	100.45	5.556	5.325	.231	1:23.1
			Average	.75	.92	1.67	6.40	.74	100.32	5.695	5.456	.239	1:22.8
			Average of all cooked 3 hours.	.75	.88	1.63	6.49	.73	100.53	5.778	5.537	.241	1:23.0
1646	1647	113	Beef, round	.29	.38	.67	5.57	.55	101.88	5.240	5.146	.094	1:54.7
1645	1647	112	.....do	.32	.43	.75	5.23	.54	99.59	5.420	5.317	.103	1:51.6
1654	1656	116	Veal, leg	.29	.96	1.25	.97	.64	102.55	5.070	4.976	.094	1:52.9
1658	1662	118	.....do	.41	.55	.99	5.58	.59	100.95	4.800	4.660	.140	1:33.3
			Average Nos. 1654 and 1658	.37	.76	1.13	3.28	.62	101.75	4.935	4.818	.117	1:41.2
			Average Nos. 1645, 1654, and 1658	.35	.65	1.00	3.93	.59	101.03	5.096	4.984	.112	1:44.5
1644	1647	111	Beef, round	.40	.57	.97	5.75	.69	100.67	5.590	5.462	.128	1:42.7
1720	1722	131	.....do	.65	.15	.80	11.61	.51	100.11	5.309	5.100	.209	1:24.4
			Average	.53	.36	.89	8.68	.60	100.39	5.450	5.281	.169	1:31.2
1665	1668	121	Beef, neck	.32	.55	.87	13.68	.47	100.28	5.039	4.937	.102	1:48.4
1673	1676	123	Beef, rump	.47	.43	.90	42.03	.33	100.95	3.245	3.094	.151	1:20.5
1703	1705	125	.....do	.29	.34	.63	23.36	.43	99.89	4.433	4.340	.093	1:46.7
			Average Nos. 1673 and 1703	.38	.39	.77	32.70	.38	100.42	3.839	3.717	.122	1:30.5
1669	1672	122	Beef, flank	.04	.17	.21	34.16	.24	101.05	3.210	3.196	.014	1:23.3
1653	1656	115	Veal, leg	.69	1.00	1.69	1.31	.75	102.51	5.360	5.138	.222	1:23.1
1664	1662	117	.....do	.56	.76	1.32	7.77	.66	101.15	4.900	4.724	.176	1:26.8
			Average Nos. 1653 and 1664	.63	.88	1.51	4.54	.71	101.83	5.130	4.931	.199	1:24.8
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	.43	.50	.93	17.46	.51	100.83	4.636	4.499	.137	1:32.8
1639	1637	107	Beef, round	.48	1.19	1.67	.....	.79	......	5.640	5.486	.154	1:35.6
1643	1647	110	.....do	.44	.57	1.01	5.66	.74	100.61	5.370	5.229	.141	1:37.1
1721	1722	132	.....do	.65	.50	1.15	9.01	.63	99.89	5.324	5.116	.208	1:24.6
			Average	.52	.75	1.27	7.34	.72	100.25	5.445	5.277	.168	1:31.4
1704	1705	126	Beef, rump	.53	.72	1.25	16.07	.68	100.59	4.583	4.413	.170	1:26.0
1652	1656	114	Veal, leg	1.12	1.67	2.79	1.59	1.01	101.17	5.310	4.952	.358	1:13.8
			Average Nos. 1639, 1643, 1652, 1704, and 1721	.64	.93	1.57	8.09	.77	100.57	5.246	5.039	.207	1:24.3
			Average of all cooked 5 hours.	.47	.65	1.12	11.84	.60	100.87	4.932	4.782	.150	1:31.9
			Average of all cooked 3 and 5 hours	.60	.75	1.35	9.34	.66	100.71	5.314	5.123	.191	1:26.8

Table 101.—*Chemical composition of meats cooked by boiling (calculated to water-free basis).*

Laboratory No.	Raw meat used, No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Proteid.		
				At beginning.	During cooking.		Insoluble.	Soluble.	Total.
				°C.	°C.	*Hrs.*	*Per ct.*	*Per ct.*	*Per ct.*
1642	1640	109	Beef, round	Cold.	85	3	87.45	0.35	87.80
1754	1753	137	do	Cold.	85	3	80.00	.46	80.46
			Average				83.73	.40	84.13
1756	1753	139	Beef, round (browned)	Cold.	85	3	76.36	.40	76.76
			Average Nos. 1642, 1754, and 1756				81.27	.40	81.67
1746	1741	136	Beef, round (browned)	85	85	3	78.11	.35	78.46
1769	1764	145	Beef, round	85	85	3	78.59	.50	79.09
1780	1775	154	do	85	85	3	80.38	.29	80.67
			Average Nos. 1769 and 1780				79.48	.40	79.88
			Average Nos. 1746, 1769, and 1780				79.03	.38	79.41
1641	1640	108	Beef, round	100	85	3	87.55	.93	88.48
1744	1741	134	do	100	85	3	82.43	.78	83.21
1768	1764	144	do	100	85	3	75.21	.51	75.72
1779	1775	153	do	100	85	3	77.48	.44	77.92
			Average				80.66	.67	81.33
1755	1753	138	Beef, round	Cold.	100	3	79.16	1.00	80.16
1757	1753	140	Beef, round (browned)	Cold.	100	3	79.26	1.13	80.39
			Average				79.21	1.07	80.28
1743	1741	133	Beef, round	100	100	3	81.67	.78	82.45
1745	1741	135	Beef, round (browned)	100	100	3	77.17	.57	77.74
			Average				79.42	.68	80.10
			Average of all cooked 3 hours				80.06	.61	80.67
1646	1647	113	Beef, round	Cold.	65	5	86.03	.73	86.76
1645	1647	112	do	Cold.	85	5	81.85	.89	82.74
1654	1656	116	Veal, leg	Cold.	85	5	97.12	1.89	99.01
1658	1662	118	do	Cold.	85	5	81.52	.91	82.43
			Average Nos. 1654 and 1658				89.32	1.40	90.72
			Average Nos. 1645, 1654, and 1658				86.83	1.23	88.06
1644	1647	111	Beef, round	100	85	5	82.80	.71	83.51
1720	1722	131	do	100	85	5	70.98	.36	71.34
			Average				76.89	.54	77.43
1665	1668	121	Beef, neck	100	85	5	67.26	.42	67.68
1673	1676	123	Beef, rump	100	85	5	30.75	.62	31.37
1703	1705	125	do	100	85	5	51.78	.74	52.52
			Average Nos. 1673 and 1703				41.27	.68	41.95
1669	1672	122	Beef, flank	100	85	5	36.57	.75	37.32
1653	1656	115	Veal, leg	100	85	5	94.81	1.47	96.28
1664	1662	117	do	100	85	5	76.61	.84	77.45
			Average Nos. 1653 and 1664				85.71	1.16	86.87
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720				63.94	.74	64.68

Table 101.—*Chemical composition of meats cooked by boiling (calculated to water-free basis)*—Continued.

Laboratory No.	Raw meat used, No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Proteid.		
				At beginning.	During cooking.		Insoluble.	Soluble.	Total.
				°C.	*°C.*	*Hrs.*	*Per ct.*	*Per ct.*	*Per ct.*
1639	1637	107	Beef, round	100	100	5	82.64	2.40	85.04
1643	1647	110	....do	100	100	5	80.45	2.33	82.78
1721	1722	132	....do	100	100	5	73.27	1.31	74.58
			Average				78.79	2.01	80.80
1704	1705	126	Beef, rump	100	100	5	59.30	2.00	61.30
1652	1656	114	Veal, leg	100	100	5	86.50	1.25	87.75
			Average Nos. 1639, 1643, 1652, 1704, and 1721				76.43	1.86	78.29
			Average of all cooked 5 hours				72.95	1.16	74.11
			Average of all cooked 3 and 5 hours				76.19	.88	77.07

Laboratory No.	Raw meat used, No.	Cooking experiment No.	Kind of meat.	Organic extractives.			Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Nonproteid nitrogen.
				Nitrogenous.	Nonnitrogenous.	Total.						
				P. ct	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1642	1640	109	Beef, round	1.07	1.40	2.47	9.80	1.27	101.34	11.393	14.048	0.345
1754	1753	137	....do	1.78	1.87	3.65	15.54	1.60	101.25	13.446	12.873	.573
			Average	1.42	1.64	3.06	12.67	1.44	101.30	13.920	13.461	.459
1756	1753	139	Beef, round (browned)	1.75	1.75	3.50	18.70	1.57	100.53	12.845	12.282	.563
			Average Nos. 1642, 1754, and 1756	1.53	1.67	3.20	14.68	1.48	101.04	13.561	13.068	.494
1746	1741	136	Beef, round (browned)	1.68	2.09	3.77	16.37	1.61	100.21	13.094	12.554	.540
1769	1764	145	Beef, round	2.18	2.02	4.20	15.79	2.09	101.17	13.353	12.654	.699
1780	1775	154	....do	1.79	2.05	3.84	14.77	1.90	101.18	13.479	12.907	.572
			Average Nos. 1769 and 1780	1.99	2.04	4.03	15.28	2.00	101.18	13.416	12.781	.636
			Average Nos. 1746, 1769, and 1780	1.88	2.05	3.93	15.64	1.87	100.85	13.309	12.705	.604
1641	1640	108	Beef, round	.81	1.10	1.91	10.69	1.22	102.30	14.418	14.157	.261
1744	1741	134	....do	1.88	2.56	4.44	11.47	1.73	100.85	13.917	13.314	.603
1768	1764	144	....do	2.40	3.11	5.51	18.23	2.16	101.62	12.889	12.115	.774
1779	1775	153	....do	2.05	2.27	4.32	17.19	1.84	101.27	13.120	12.467	.653
			Average	1.79	2.26	4.05	14.40	1.74	101.51	13.586	13.013	.573
1755	1753	138	Beef, round	1.69	2.06	3.75	16.78	1.62	102.31	13.372	12.826	.546
1757	1753	140	Beef, round (browned)	1.81	2.09	3.90	15.68	1.61	101.58	13.444	12.862	.582
			Average	1.75	2.08	3.83	16.23	1.62	101.95	13.408	12.844	.564
1743	1741	133	Beef, round	1.82	2.46	4.28	11.95	1.75	100.43	13.776	13.192	.584
1745	1741	135	Beef, round (browned)	1.68	1.85	3.53	18.06	1.71	101.06	12.978	12.438	.540
			Average	1.75	2.16	3.91	15.02	1.73	100.75	13.377	12.815	.562
			Average of all cooked 3 hours	1.74	2.05	3.79	15.08	1.69	101.22	13.466	12.906	.560

TABLE 101.—*Chemical composition of meats cooked by boiling (calculated to water-free basis)*—Continued.

Laboratory No.	Raw meat used, No.	Cooking experiment No.	Kind of meat.	Organic extractives.			Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Nonproteid nitrogen.
				Nitrogenous.	Nonnitrogenous.	Total.						
				P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1646	1647	113	Beef, round	0.78	1.03	1.81	15.03	1.48	105.08	14.135	13.882	0.253
1645	1647	112	.....do	.80	1.07	1.87	13.02	1.34	98.97	13.496	13.238	.258
1654	1656	116	Veal, leg	.92	3.06	3.98	3.09	2.04	108.12	16.140	15.842	.298
1658	1662	118	.....do	1.25	1.55	2.80	15.79	1.67	102.69	13.582	13.189	.393
			Average Nos. 1654 and 1658	1.06	2.31	3.37	9.44	1.86	105.41	14.861	14.516	.346
			Average Nos. 1645, 1654, and 1658	.99	1.89	2.88	10.63	1.68	103.26	14.406	14.090	.316
1644	1647	111	Beef, round	.98	1.39	2.37	14.07	1.69	101.64	13.674	13.362	.312
1720	1722	131	.....do	1.45	.34	1.79	25.98	1.14	100.25	11.880	11.414	.466
			Average	1.22	.87	2.09	20.03	1.42	100.95	12.777	12.388	.389
1665	1668	121	Beef, neck	.70	1.21	1.91	30.00	1.03	100.62	11.049	10.829	.220
1673	1676	123	Beef, rump	.76	.70	1.46	68.18	.54	101.55	5.264	5.019	.245
1703	1705	125	.....do	.56	.66	1.22	45.22	.83	99.79	8.581	8.403	.178
			Average Nos. 1673 and 1703	.66	.68	1.34	56.70	.69	100.67	6.923	6.711	.212
1669	1672	122	Beef, flank	.07	.32	.39	63.80	.45	101.96	5.996	5.971	.025
1653	1656	115	Veal, leg	2.07	3.00	5.07	3.93	2.25	107.53	16.072	15.405	.667
1664	1662	117	.....do	1.47	1.99	3.46	20.38	1.73	103.02	12.851	12.392	.459
			Average Nos. 1653 and 1664	1.77	2.50	4.27	12.16	1.99	105.28	14.462	13.899	.563
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	1.01	1.20	2.21	33.95	1.21	102.05	10.671	10.349	.322
1639	1637	107	Beef, round	1.19	2.95	4.14	......	1.96	......	13.988	13.607	.381
1643	1647	110	.....do	1.12	1.44	2.56	14.34	1.87	101.55	13.602	13.245	.357
1721	1722	132	.....do	1.51	1.17	2.68	21.01	1.47	99.74	12.416	11.933	.483
			Average	1.27	1.85	3.12	17.68	1.77	100.65	13.335	12.928	.407
1704	1705	126	Beef, rump	1.18	1.60	2.78	35.72	1.51	101.31	10.190	9.808	.382
1652	1656	114	Veal, leg	3.18	4.74	7.92	4.51	2.86	103.04	15.055	14.040	1.015
			Average Nos. 1639, 1643, 1652, 1704, and 1721	1.64	2.38	4.02	18.90	1.94	101.41	13.050	12.526	.524
			Average of all cooked 5 hours	1.18	1.66	2.84	24.63	1.52	102.25	12.234	11.857	.377
			Average of all cooked 3 and 5 hours	1.43	1.84	3.27	20.17	1.60	101.77	12.790	12.331	.459

It will be seen that the average results obtained from analysis of 31 samples of different cuts of beef and veal which had been cooked by boiling, under the various conditions indicated, were as follows: Water 57.50 per cent, insoluble proteid 31.57 per cent, soluble proteid 0.38 per cent, total proteid 31.95 per cent, nitrogenous extractives 0.60 per cent, nonnitrogenenous extractives 0.75 per cent, total organic extractives 1.35 per cent, fat 9.34 per cent, ash 0.66 per cent, making a total of 100.71 per cent. The average nitrogen values for these samples of boiled meats were: Total nitrogen 5.314 per cent, proteid nitrogen

5.123 per cent, and nonproteid nitrogen 0.191 per cent. The ratio of nonproteid to proteid nitrogen was 1:26.8.

If these results are compared with those obtained for the corresponding raw meats, it will be seen that there is a marked difference between the chemical composition of uncooked meats and meats cooked in hot water, the analysis of the 13 samples of the corresponding uncooked meats (beef and veal) being as follows: Water 70.08[a] per cent, insoluble proteid 15.63 per cent, soluble proteid 2.30 per cent, total proteid 17.93 per cent, nitrogenous extractives 1.09 per cent, non-nitrogenous 1.63 per cent, total organic extractives 2.72 per cent, fat 9.65 per cent, ash 1.04 per cent, making a total of 100.67 per cent. The average nitrogen values for the uncooked meats were: Total nitrogen 3.219 per cent, proteid nitrogen 2.868 per cent, and nonproteid nitrogen, 0.351 per cent. The ratio of nonproteid to proteid nitrogen was 1: 8.25.

It is evident that there is a decided decrease in water content of the meat when it is boiled in water. The average amount of water in the 14 samples of uncooked meats was 70.08 per cent, while in the 31 samples cooked in hot water it was only 57.50 per cent. This corresponds with results previously obtained in this laboratory, and all go to show that there is always a loss of water when meats are cooked in hot water. It follows from the above consideration that the cooked meats will contain a considerable higher percentage than the raw of some or all of the constituents other than water. This is especially true of the insoluble proteid, which amounts to 31.57 per cent in the cooked meats and to only 15.63 per cent in the uncooked meats; that is to say, the percentage amount of insoluble proteid in the cooked meats is slightly more than twice as great as in the raw meats. It must not, however, be supposed that this greater proportion of proteid in the cooked meats is due entirely to the decrease in the proportion of water. Some of the increase is due to the coagulation of albumin during the process of cooking which renders some soluble proteid insoluble.

Indeed, one of the most pronounced differences in the chemical composition of cooked and uncooked meats occurs in the amount of soluble albumin present. The average quantity of soluble proteid in the 13 samples of raw meat was 2.30 per cent, and in the 31 samples of boiled meat only 0.38 per cent. In other words, during the cooking of the meat 1.92 per cent of the proteid present in the uncooked meat in a soluble form was rendered insoluble by coagulation. The actual nature of this change will probably be better understood after a study of the water-free substances. In the water-free substance of the cooked meats there is 76.19 per cent of the insoluble proteid, 0.88 per cent of soluble proteid, and 77.07 per cent of total proteid. On the other hand, the insoluble proteid forms 56.37 per cent, the soluble proteid 8.39 per cent, and the total proteid 64.76 per cent of the water-free substance of the uncooked meats.

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[a] In the case of water the average represents 14 samples.

This difference between the cooked and uncooked meat may be further illustrated by comparing the ratios of the soluble to the insoluble proteid. The ratio of the soluble proteid to the insoluble proteid in the case of the uncooked meats is 1:6.7, and in the case of the cooked meats is 1:86.8.

Another characteristic difference which is readily observed between the chemical composition of uncooked meats and meats cooked by boiling occurs in the quantities of organic extractives which they contain, both the nitrogen and the nonnitrogenous extractives being present in much smaller proportions in the freshly cooked meats than in the raw. The average values were, nitrogenous extractives 1.09 per cent, nonnitrogenous 1.63 per cent, and total organic extractives 2.72 per cent, in the 13 samples of uncooked meats (beef and veal). The analyses of the 31 samples of meats (beef and veal) cooked in hot water show that they contained the following: Nitrogenous extractives 0.60 per cent, nonnitrogenous extractives 0.75 per cent, and total organic extractives 1.35 per cent. If the figures are calculated to the water-free basis, they will be more strictly comparable. On this basis the uncooked meats contained upon an average 3.98 per cent of nitrogenous extractives, 5.94 per cent of nonnitrogenous extractives, and 9.93 per cent of total organic extractives, and the cooked meats contained 1.45 per cent of nitrogenous extractives, 1.84 per cent of nonnitrogenous extractives, and 3.27 per cent of total organic extractives. In other words, the boiled meats contained a little less than one-third as much of the organic extractives as the raw. Examination of the broths resulting in the cooking showed that somewhat more than two-thirds of these extractive constituents of the meat entered the broth during the contact of the meat with the water in which it was cooked.

The amount of fat contained in the fresh substance of the uncooked and cooked meats is about the same, the average for 13 samples of raw meats being 9.65 per cent, and for 31 samples of boiled meats 9.34 per cent. On a water-free basis the percentage of fat in the raw meats is 27.40 and in the cooked meats only 20.17. So it appears that during the cooking there is actually a loss of fat. This has also been demonstrated by analysis of the resulting broths, which are found to contain some of the meat fat.

The data presented show plainly that the ash content of meat cooked in hot water is much less than that of the same meat before cooking. The analyses of 13 samples of uncooked meats gave an average of 1.09 per cent of ash, and of 31 samples of boiled meats 0.66 per cent. Calculating these results to a water-free basis, the ash in the raw meats is 3.74 per cent and only 1.60 per cent in the cooked meats.

From what has been said regarding the proteid and nitrogenous organic extractives, it follows that the meat cooked by boiling would contain a considerably greater proportion of proteid nitrogen and a smaller proportion of nonproteid nitrogen than the raw. The boiled meat contained 5.123 per cent of proteid nitrogen and 0.191 per cent of nonproteid nitrogen, while the raw meats contained 2.868 per cent of proteid nitrogen and 0.351 per cent of nonproteid nitrogen. This difference in the relation between the amounts of proteid and nonproteid nitrogen in the boiled and the raw meats may be strikingly shown by calculating the ratio of the nonproteid to the proteid nitrogen in the two cases. Thus the ratio of the nonproteid to the proteid nitrogen in the cooked meats is 1:26.8, while in the uncooked meats it is 1:8.2

There is another especially interesting question connected with the results here presented, namely, What influences do slow and rapid cooking, low and high temperature, and other variations in the methods of cooking of meats in water have upon their chemical composition and nutritive value? In order that such differences, if they exist, may be more readily studied, a table has been prepared in which a summary of the average composition of meats cooked by different methods is given, together with the average composition of the 13 samples of raw meats:

TABLE 102.—*Summary showing the chemical composition of boiled and uncooked meats.*

Methods of cooking.	Temperature.		Duration of cooking.	Water.	Proteid.		
	At beginning.	During cooking.			Insoluble.	Soluble.	Total.
BOILED 3 HOURS.	°C.	°C.	*Hours.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Experiments Nos. 109, 137, 139	Cold.	85	3	57.79	34.25	0.17	34.42
Experiments Nos. 136, 145, 154	85	85	3	56.06	34.74	.16	34.90
Experiments Nos. 108, 134, 144, 153	100	85	3	57.47	34.28	.28	34.56
Average of 10 tests (Nos. 108, 109, 134, 136, 137, 139, 144, 145, 153, 154)	....	85	3	57.14	34.41	.21	34.62
Experiments Nos. 138, 140	Cold.	100	3	56.33	34.59	.47	35.06
Experiments Nos. 133, 135	100	100	3	57.42	33.81	.29	34.10
Average of 4 tests (Nos. 133, 135, 138, 140)	....	100	3	56.87	34.20	.38	34.58
Average of above 14 tests	....	....	3	57.07	34.35	.26	34.61
BOILED 5 HOURS.							
Experiment No. 113	Cold.	65	5	62.93	31.89	.27	32.16
Experiments Nos. 112, 116, 118	Cold.	85	5	64.36	30.73	.42	31.15
Experiments Nos. 111, 115, 117, 121, 122, 123, 125, 131	100	85	5	53.82	27.79	.33	28.12
Average of 6 tests (Nos. 111, 118, 121, 123, 125, 131)	....	85	5	56.70	28.59	.36	28.95
Experiments Nos. 107, 110, 132, 126, 114	100	100	5	59.41	30.73	.76	31.49
Average of above 17 tests	....	....	5	57.86	29.41	.47	29.88
Average of above 31 tests with boiled meat	....	....	....	57.50	31.57	.38	31.95
RAW MEAT.							
Average of 13 tests	....	....	....	70.08	15.63	2.30	17.93

TABLE 102.—*Summary showing the chemical composition of boiled and uncooked meats*—Continued.

Method of cooking.	Organic extractives.			Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Nonproteid nitrogen.	Ratio of nonproteid to proteid nitrogen.
	Nitrogenous.	Nonnitrogenous.	Total.							
BOILED 3 HOURS.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
Experiments Nos. 109, 137, 139	0.65	0.71	1.36	6.21	0.63	100.41	5.716	5.507	0.209	1:26.3
Experiments Nos. 136, 145, 154	.83	.90	1.73	6.87	.82	100.38	5.849	5.583	.266	1:21.0
Experiments Nos. 108, 134, 144, 153.	.76	.96	1.72	6.15	.74	100.64	5.774	5.529	.245	1:22.6
Average of 10 tests (Nos. 108, 109, 134, 136, 137, 139, 144, 145, 153, 154)	.75	.87	1.62	6.39	.73	100.50	5.779	5.539	.240	1:23.1
Experiments Nos. 138, 140	.77	.91	1.68	7.09	.71	100.85	5.856	5.610	.246	1:22.8
Experiments Nos. 133, 135	.75	.92	1.67	6.40	.74	100.32	5.695	5.456	.239	1:22.8
Average of 4 tests (Nos. 133, 135, 138, 140)	.76	.92	1.68	6.75	.73	100.59	5.776	5.533	.243	1:22.8
Average of above 14 tests	.75	.88	1.63	6.49	.73	100.53	5.778	5.537	.241	1:23.0
BOILED 5 HOURS.										
Experiment No. 113	.29	.38	.67	5.57	.55	101.88	5.240	5.146	.094	1:54.7
Experiments Nos. 112, 116, 118	.35	.65	1.00	3.93	.59	101.03	5.096	4.984	.112	1:44.5
Experiments Nos. 111, 115, 117, 121, 122, 123, 125, 131	.43	.50	.93	17.46	.51	100.83	4.636	4.499	.137	1:32.8
Average of 6 tests (Nos. 111, 118, 121, 123, 125, 131)	.41	.54	.95	13.77	.53	100.88	4.761	4.631	.130	1:35.6
Experiments Nos. 107, 110, 132, 126, 114	.64	.93	1.57	8.09	.77	100.57	5.246	5.039	.207	1:24,3
Average of above 17 tests	.47	.65	1.12	11.84	.60	100.87	4.932	4.782	.150	1:31.9
Average of above 31 tests with boiled meat	.60	.75	1.35	9.34	.66	100.71	5.314	5.123	.191	1:26.8
RAW MEAT.										
Average of 13 tests	1.09	1.63	2.72	9.65	1.04	100.67	3.219	2.868	.351	1: 8.2

Examination of the data presented in Table 102 makes it evident that the different methods of boiling do not produce differences in chemical composition which are nearly as marked as the differences between the chemical composition of boiled and raw meats. It is interesting in this connection to note the influence of the duration of the cooking period upon the composition of the meats. It is to be regretted that the work here reported does not contain results of cooking experiments in which similar portions from the same cut of meat had been used for cooking in boiling water for three hours and for five hours, respectively, so that strictly comparable results could be had. In the absence of such experiments, conclusions must be drawn from the average results of the experiments presented above in which different cuts of meats were used. The average composition of the fourteen samples of meats which were cooked for three hours was: Water 57.07 per cent, insoluble proteid 34.35 per cent, soluble proteid 0.26 per cent, total proteid 34.61 per cent, nitrogenous extractives 0.75 per cent, nonnitrogenous extractives 0.88 per cent, total organic extractives 1.63

per cent, fat 6.49 per cent, and ash 0.73 per cent. The average nitrogen values for the same meats were: Total nitrogen 5.778 per cent, proteid nitrogen 5.537 per cent, and nonproteid nitrogen 0.241 per cent, and the ratio of nonproteid nitrogen to proteid nitrogen was 1:23. The average composition of the seventeen samples of meats cooked for five hours was as follows: Water 57.86 per cent, insoluble proteid 29.41 per cent, soluble proteid 0.47 per cent, total proteid 29.88 per cent, nitrogenous extractives 0.47 per cent, nonnitrogenous extractives 0.65 per cent, total organic extractives 1.12 per cent, fat 11.84 per cent, and ash 0.60 per cent. The average nitrogen values were: Total nitrogen 4.932 per cent, proteid nitrogen 4.782 per cent, and nonproteid nitrogen 0.150 per cent, and the ratio of nonproteid to proteid nitrogen was 1:31.9.

It will be seen that the slight differences in the chemical composition of the meats cooked for three hours and those cooked for five hours are in part due to the greater proportion of fat in the meats cooked for the longer period. Were these average results calculated to the basis of fat-free and water-free substance, and so made strictly comparable with each other, the differences would be even smaller.

From the data here available, it appears that meats cooked in boiling water for five hours contain a somewhat higher amount of soluble proteids but a slightly smaller amount of other soluble materials—namely, nitrogenous extractives, nonnitrogenous extractives, total organic extractives, and ash—than do those cooked in hot water for only three hours. The ratio of nonproteid to proteid nitrogen indicates this fact. In the meats cooked for three hours this ratio is 1:23, while in the meats cooked for five hours it is 1:31.9.

In the next place it will be of interest to see what the data here presented indicate regarding the comparative chemical composition of meats cooked in water by different methods, the time being the same. Careful study in this laboratory has shown that when meat is cooked in water at 80 to 85° C., placing the meat in hot or cold water at the start has little effect on the amount of the nutrients of the meat which pass into the broth. It must be remembered that the meat used in the cooking experiments here reported was in the form of 1 to 2 inch cubes or else in pieces weighing from 1 to 2 pounds.

Referring to Table 102, page 110, it will be noted that in the first group of three experiments (Nos. 109, 137, and 139) the meat was first placed in cold water and the temperature so regulated that it took one hour for the water to reach 85° C. The meat was then cooked for three hours at that temperature. In the second group of three experiments (Nos. 136, 145, and 154) the meat was put directly into water having a temperature of 85° C. and cooked at that temperature for three hours. In the group of four experiments (Nos. 108, 134, 144, and 153) the meat was placed first in boiling water for ten minutes and the temperature allowed to fall to 85° C., after which the cooking was continued at this temperature, the total time of cooking being three hours.

The table shows little difference in the chemical composition of the resulting cooked meats, the amount of water-soluble proteid, total proteid, and fat being practically the same in the three groups. The soluble proteid was slightly higher in the last group; that is, where the meat was first put into boiling water and then cooked at 85° C. The amounts of organic extractives, both nitrogenous and nonnitrogenous, were somewhat lower in the first group—that is, where the meat was first put into cold water—than in the other two groups. The difference, however, is not great, being only 0.37 per cent. The ash was also lower in the first group than in the other two and somewhat higher in the second group than in the third. Further, there was but little difference in the ratio of the nonproteid to the proteid nitrogen in the three groups. This is especially true in the second and third groups of experiments in which the ratio was 1:21 and 1:22.6, respectively. In the first group the ratio was 1:26.3.

Referring again to Table 102, page 110, the results are given of experiment No. 113, in which the meats were cooked for a period of five hours, the meat being placed in cold water at first, the temperature then being so adjusted that it took one hour for the water to reach 65° C., and cooking continued at this temperature. In the next group (experiments Nos. 112, 116, and 118) the meat was placed in water, cold at the start, and the temperature so regulated that it took one hour for the water to reach 85° C., at which temperature the meat was kept for five hours. In the third group (experiments Nos. 111, 115, 117, 121, 122, 123, 125, and 131) the meat was first placed in water near the boiling point for ten minutes, after which the temperature was allowed to drop to 85° C. and the cooking continued for a period covering five hours.

An examination of the results of these three groups of experiments reveals no marked difference in the chemical composition of the cooked meat due to the method of cooking. To be sure the average percentage of fat in the third group is much higher than it is in the first and second groups, but this is not due, however, to the method used in cooking the meat but to the character of the meat used. In consequence of this higher content of fat in this third group, it follows that the average proportion of water, protein, and other constituents for this group is correspondingly lower than for the other two groups. This fact should be kept in mind in considering the quantities of the soluble constituents in this series. The soluble proteid, the nitrogenous and the nonnitrogenous extractives, are again somewhat lower when the meat was put in cold water and then cooked at 65° C. than they are in the two other groups. However, the differences are not great, the maximum difference in the total organic extractives being only 0.33 per cent. The percentage of ash is practically the same in the three groups, if the content of fat is taken into consideration. There is a greater difference in the ratio of the nonproteid to the proteid nitrogen than there was in the set of three experiments described immediately above, the ratio being 1:54.7 in the first group, 1:44.5 in the second, and 1:32.8 in the third group.

It seems fair to conclude that, everything considered, the results here presented show that only a very slight difference in the chemical composition of similar meats results when they are cooked by immersing them first in cold water and then in water at 85° C., or by placing them in boiling water and then continuing the cooking at 85° C. for five hours.

It is commonly supposed that when meat is plunged into boiling water the albumin coagulates and forms a crust which prevents the escape of nutritive materials into the broth. It is also believed that if a rich broth is desired, to be used either as a soup or with the meat as a stew, it is more desirable to place the meat in cold water at the start. From the results of these experiments, however, it is evident that under these conditions there can be little advantage in using either hot or cold water at the beginning.

COMPOSITION OF MEATS COOKED BY ROASTING, BROILING, SAUTÉING, AND FRYING.

The final results of the studies of the changes in composition of meats cooked by roasting, broiling, sautéing, and frying are given in Tables 103 and 104. It seems best to group the results of the analyses of meats cooked by these different methods, in the first place because only a few tests have as yet been made on each of the methods, and in the second place because the nature of the chemical changes brought about by these methods of applying dry heat are apparently quite similar, if we may judge from the results obtained.

TABLE 103.—*Chemical composition of meats cooked by roasting, broiling, sautéing, and frying (fresh substance).*

Laboratory No.	Raw meat used, No.	Cooking experiment No.	Kind of meat.	Water.	Proteid.			Organic extractives.		
					Insoluble.	Soluble.	Total.	Nitrogenous.	Non-nitrogenous.	Total.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1770	1764	146	Beef, round, pot roast...	51.95	34.22	0.31	34.53	1.40	1.69	3.09
1781	1775	155	.....do.....................	52.96	34.19	.42	34.61	1.11	1.17	2.28
			Average	52.46	34.20	.37	34.57	1.26	1.43	2.69
1771	1764	147	Beef, round, roast.......	64.63	20.70	.75	21.45	1.36	1.55	2.91
1782	1775	156	.....do.....................	68.58	21.96	1.23	23.19	.94	1.27	2.21
			Average	66.61	21.33	.99	22.32	1.15	1.41	2.56

TABLE 103.—*Chemical composition of meats cooked by roasting, broiling, sautéing, and frying (fresh substance)*—Continued.

Laboratory No.	Raw meat used, No.	Cooking experiment No.	Kind of meat.	Water.	Proteid.			Organic extractives.		
					Insoluble.	Soluble.	Total.	Nitrogenous.	Non-nitrogenous.	Total.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1660	1662	120	Veal, leg, roast	68.35	23.28	0.41	23.69	1.34	1.89	3.23
			Average Nos. 1660, 1771, and 1782	67.19	21.98	.80	22.78	1.21	1.57	2.78
1778	1775	152	Beef, round, gas broiled	66.26	21.95	.83	22.78	1.38	1.62	3.00
1766	1764	142	Beef, round, pan broiled	65.61	20.94	1.37	22.31	1.46	1.72	3.18
1777	1775	151	.....do	65.74	24.16	.58	24.74	1.48	1.72	3.20
			Average Nos. 1766 and 1777	65.68	22.55	.98	23.53	1.47	1.72	3.19
1674	1676	124	Beef, rump, pan broiled	27.46	21.24	.27	21.51	1.07	1.33	2.40
1659	1662	119	Veal, leg, pan broiled	65.33	26.29	.42	26.71	1.33	1.84	3.17
			Average Nos. 1659, 1674, 1766, and 1777	56.01	23.16	.66	23.82	1.34	1.65	2.99
1765	1764	141	Beef, round, sautéed	64.02	21.48	1.03	22.51	1.38	1.69	3.07
1776	1775	150	.....do	66.66	22.04	.73	22.77	1.37	1.61	2.98
			Average	65.31	21.76	.88	22.64	1.38	1.65	3.03
1767	1764	143	Beef, round, fried	57.78	27.06	.53	27.59	1.62	1.83	3.45
			Average all beef[a]	62.42	24.87	.78	25.65	1.36	1.58	2.94
			Average all veal	66.84	24.79	.41	25.20	1.34	1.87	3.21
			Average beef[a] and veal	63.16	21.86	.72	25.58	1.36	1.63	2.99
			Average roasts, gas broiled, pan broiled, and sautéed[a]	66.14	22.54	.82	23.36	1.35	1.65	3.00

Laboraory No.	Raw meat used, No.	Cooking experiment No.	Kind of meat.	Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Non-proteid nitrogen.	Ratio of non-proteid to proteid nitrogen.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
1770	1764	146	Beef, round, pot roast	9.66	1.21	100.44	5.972	5.524	0.448	1:12.3
1781	1775	155	.....do	9.87	1.10	100.82	5.891	5.537	.354	1:15.6
			Average	9.77	1.16	100.63	5.932	5.531	.401	1:13.8
1771	1764	147	Beef, round, roast	9.50	1.17	99.66	3.870	3.432	.438	1: 7.8
1782	1775	156	.....do	5.42	1.16	100.56	4.011	3.711	.300	1:12.4
			Average	7.46	1.17	100.11	3.941	3.572	.369	1: 9.7
1660	1662	120	Veal, leg, roast	4.65	1.36	101.28	4.220	3.791	.429	1: 8.8
			Average Nos. 1660, 1771, and 1782	6.52	1.23	100.50	4.034	3.645	.389	1: 9.4
1778	1775	152	Beef, round, gas broiled	7.64	1.22	100.90	4.088	3.645	.443	1: 8.2
1766	1764	142	Beef, round, pan broiled	8.18	1.19	100.47	4.037	3.569	.468	1: 7.6
1777	1775	151	.....do	5.83	1.24	100.75	4.435	3.959	.476	1: 8.3
			Average Nos. 1766 and 1777	7.01	1.22	100.61	4.236	3.764	.472	1: 8.0

[a] Not including No. 1674.

TABLE 103.—*Chemical composition of meats cooked by roasting, broiling, sautéing, and frying (fresh substance)*—Continued.

Laboratory No.	Raw meat used, No.	Cooking experiment No.	Kind of meat.	Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Non-proteid nitrogen.	Ratio of non-proteid to proteid nitrogen.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1674	1676	124	Beef, rump, pan broiled..........	47.39	1.18	99.94	3.786	3.442	0.344	1:10.0
1659	1662	119	Veal, leg, pan broiled.	5.20	1.44	101.85	4.700	4.274	.426	1:10.0
			Average Nos. 1659, 1674, 1766, and 1777	16.65	1.26	100.75	4.240	3.811	.429	1: 8.9
1765	1764	141	Beef, round, sautéed..	9.88	1.18	100.66	4.044	3.601	.443	1: 8.1
1776	1775	150	.....do................	6.34	1.17	99.92	4.083	3.643	.440	1: 8.3
			Average	8.11	1.18	100.29	4.064	3.622	.442	1: 8.2
1767	1764	143	Beef, round, fried	10.42	1.43	100.67	4.934	4.414	.520	1: 8.5
			Average all beef[a]	8.27	1.21	100.49	4.537	4.104	.433	1: 9.5
			Average all veal.	4.93	1.40	101.67	4.460	4.033	.427	1: 9.4
			Average beef and veal[a].....	7.72	1.24	100.69	4.524	4.092	.432	1: 9.5
			Average roasts, gas broiled, pan broiled, and sautéed[a].	6.96	1.24	100.71	4.166	3.736	.430	1:7.8

[a] Not including No. 1674.

TABLE 104.—*Chemical composition of meats cooked by roasting, broiling, sautéing, and frying (water-free basis).*

Laboratory No.	Raw meat used. No.	Cooking experiment No.	Kind of meat.	Proteid.			Organic extractives.		
				Insoluble.	Soluble.	Total.	Nitrogenous.	Nonnitrogenous.	Total.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1770	1764	146	Beef, round, pot roast..........	74.01	0.65	74.66	2.58	3.16	5.74
1781	1775	155	.....do........................	72.68	.89	73.57	2.36	2.49	4.85
			Average.................	73.35	.77	74.12	2.47	2.83	5.30
1771	1764	147	Beef, round, roast.............	58.54	2.10	60.64	3.84	4.38	8.22
1782	1775	156	.....do........................	69.90	3.91	73.81	2.99	4.04	7.03
			Average.................	64.22	3.01	67.23	3.42	4.21	7.63
1660	1662	120	Veal, leg, roast...............	73.55	1.30	74.85	4.23	5.97	10.20
			Average Nos. 1660, 1771, and 1782............	67.33	2.44	69.77	3.69	4.80	8.49
1778	1775	152	Beef, round, gas broiled.......	65.06	2.46	67.52	4.09	4.80	8.89
1766	1764	142	Beef, round, pan broiled.......	60.89	3.98	64.87	4.25	5.00	9.25
1777	1775	151	.....do........................	70.52	1.69	72.21	4.32	5.02	9.34
			Average Nos. 1766 and 1777.................	65.70	2.84	68.54	4.29	5.01	9.30
1674	1676	124	Beef, rump, pan broiled........	29.28	.37	29.65	1.48	1.83	3.31
1659	1662	119	Veal, leg, pan broiled.........	75.83	1.21	77.04	3.84	5.31	9.15
			Average Nos. 1659, 1674, 1766, and 1777..........	59.13	1.81	60.94	3.47	4.29	7.76
1765	1764	141	Beef, round, sautéed...........	59.69	2.87	62.56	3.84	4.70	8.54
1776	1775	150	.....do........................	66.11	2.19	68.30	4.11	4.83	8.94
			Average.................	62.90	2.53	65.43	3.98	4.77	8.75

TABLE 104.—*Chemical composition of meats cooked by roasting, broiling, sautéing, and frying (water-free basis)*—Continued.

Laboratory No.	Raw meat used, No.	Cooking experiment No.	Kind of meat.	Proteid.			Organic extractives.		
				Insoluble.	Soluble.	Total.	Nitrogenous.	Nonnitrogenous.	Total.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1767	1764	143	Beef, round, fried	64.09	1.26	65.35	3.84	4.33	8.17
			Average all beef[a]	66.15	2.20	68.35	3.63	4.28	7.91
			Average all veal	74.69	1.26	75.95	4.04	5.64	9.68
			Average all beef[a] and veal	67.57	2.05	69.62	3.70	4.51	8.21
			Average roasts, gas broiled, pan broiled, and sautéed	66.67	2.42	69.09	3.96	4.90	8.86

Laboratory No.	Raw meat used, No.	Cooking experiment No.	Kind of meat.	Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Nonproteid nitrogen.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1770	1764	146	Beef, round, pot roast	18.51	2.34	101.25	12.429	11.946	0.483
1781	1775	155	do	20.98	2.34	101.71	12.523	11.772	.751
			Average	19.75	2.34	101.48	12.476	11.859	.617
1771	1764	117	Beef, round, roast	26.86	3.31	99.03	10.941	9.702	1.239
1782	1775	156	do	17.25	3.69	101.78	12.766	11.810	.956
			Average	22.06	3.50	100.41	11.854	10.756	1.098
1660	1662	120	Veal, leg, roast	14.69	4.30	104.04	13.333	11.976	1.357
			Average Nos. 1660, 1771, and 1782	19.60	3.77	101.62	12.347	11.163	1.184
1778	1775	152	Beef, round, gas broiled	22.64	3.62	102.67	12.116	10.803	1.313
1766	1764	142	Beef, round, pan broiled	23.79	3.46	101.37	11.739	10.379	1.360
1777	1775	151	do	17.02	3.62	102.19	12.945	11.554	1.391
			Average Nos. 1766 and 1777	20.41	3.54	101.78	12.342	10.967	1.376
1674	1676	124	Beef, rump, pan broiled	65.33	1.63	99.92	5.218	4.744	.474
1659	1662	119	Veal, leg, pan broiled	15.00	4.15	105.34	13.556	12.326	1.230
			Average Nos. 1659, 1674, 1766, and 1777	30.29	3.22	102.21	10.865	9.751	1.114
1765	1764	141	Beef, round, sautéed	27.46	3.28	101.84	11.240	10.010	1.230
1776	1775	150	do	19.02	3.51	99.77	12.247	10.928	1.319
			Average	23.24	3.40	100.81	11.744	10.469	1.275
1767	1764	143	Beef, round, fried	24.68	3.39	101.59	11.687	10.456	1.231
			Average all beef[a]	21.82	3.26	101.32	12.064	10.936	1.128
			Average all veal	14.85	4.23	104.69	13.445	12.151	1.294
			Average all beef[a] and veal	20.66	3.42	101.88	12.294	11.139	1.155
			Average roasts, gas broiled, pan broiled, and sautéed	20.42	3.66	102.00	12.321	11.055	1.266

[a] Not including No. 1674.

Upon examining Table 103 it will be readily noted that the amount of water contained in meats cooked by roasting, gas broiling, pan broiling, and sautéing is decidedly greater than it is in meats cooked by boiling or in meats cooked by pot roasting and frying, the average water content in 9 samples of roast, gas broiled, pan broiled, and sautéed meat being 66.13 per cent as compared with 57.50, the average percentage of water in 31 samples of meat cooked in hot water. Two samples of pot roasted meat showed an average of 52.46 per cent of water, while one sample of fried meat contained 57.78 per cent of water. It will be remembered that the average content of the 12 samples of uncooked meats was 70.08. Since meats cooked by roasting, gas broiling, pan broiling, and sautéing contain a considerably higher percentage of water than do meats cooked by boiling, it follows that if the losses resulting from the cooking are the same the former will be poorer in insoluble proteid, total proteid, fat, and other constituents.

As will be seen (Table 103), the percentages of insoluble and total proteid are much smaller in the roast, gas broiled, pan broiled, and sautéed than in the boiled meats. The average total proteid in the former case is 23.36 per cent and in the latter 31.95 per cent. With regard to the fat it is difficult to draw definite conclusions, since in the first place this constituent is subject to such wide variations in the uncooked meat, and in the second place the proportion of fat removed by boiling is much greater than it is in the other methods of cooking.

When we compare the soluble constituents, i. e., soluble proteids, nitrogenous and nonnitrogenous extractives, and ash of the meats cooked by roasting, gas broiling, pan broiling, pot roasting, frying, and sautéing, with those of meat cooked in hot water, striking differences are noted, all of the soluble constituents occurring in meats being found in much smaller proportion in the latter than in the others. As shown by the average of the analyses of 12 samples, pot roasted, gas broiled, pan broiled, fried, and sautéed meat contained the following: Soluble proteid 0.72 per cent, nitrogenous extractives 1.36 per cent, nonnitrogenous extractives 1.65 per cent, total organic extractives 2.99 per cent, and ash 1.24 per cent. Referring to Table 102, page 110, it will be seen that the average of 31 analyses of boiled meats gave the following: Soluble proteid 0.38 per cent, nitrogenous extractives 0.60 per cent, nonnitrogenous extractives 0.75 per cent, total extractives 1.35 per cent, and ash 0.66 per cent. It is thus evident that there is a marked difference in the chemical composition of meats cooked by methods which do not necessitate contact with water and those cooked by immersion in hot water. Meats cooked without immersion in water contain, as a rule, more than twice as much of the soluble organic and inorganic substances which have so much to do with the production of flavor as those cooked in hot water.

Another marked difference between meats cooked by the different methods is apparent in the ratio of the nonproteid to the proteid nitrogen. In the case of meats cooked by other methods than immersion in hot water, the ratio on an average was 1:9.5, as compared with 1:26.8 in the case of meats cooked in hot water. It is evident that there is a fundamental difference in the nature of the chemical changes and the losses which result when meats are cooked in hot water and when they are cooked by other methods. Such marked differences in chemical composition must undoubtedly be accompanied by differences in nutritive value, and therefore in economic value. Exactly what these differences are must be determined mainly by further investigation.

Finally, attention should be called to the fact that the available data indicate clearly that the meats cooked by methods other than immersion in hot water resemble uncooked meats in chemical composition much more than do meats cooked by boiling. This is evident in the amount of water which they contain. The average amount of water found in the analysis of 13 samples of uncooked meats was 70.08 per cent. The analysis of 12 samples of roasted, broiled, sautéed, and fried meats was 63.16 per cent, and 31 samples of boiled meats was 57.50. This closer resemblance of meats cooked by dry heat to uncooked meats is also shown by the amounts of nitrogenous and nonnitrogenous organic extractives and ash which they contain. Twelve samples of beef and veal (see pages 114 and 117), cooked by one or another of the dry methods, contained on an average 1.36 per cent nitrogenous extractives, 1.63 per cent of nonnitrogenous extractives, 2.99 per cent total organic extractives, and 1.24 per cent ash. Thirteen samples of uncooked meats gave the following average figures: 1.09 per cent nitrogenous extractives, 1.63 per cent nonnitrogenous extractives, 2.72 per cent total organic extractives, and 1.04 per cent ash. In the case of the 31 samples of boiled meats the average values were 0.60 per cent nitrogenous extractives, 0.75 per cent nonnitrogenous extractives, 1.35 per cent total organic extractives, and 0.66 per cent ash.

Meats cooked by dry heat also resemble raw meats in the ratio of nonproteid to proteid nitrogen, the value being 1:9.5 and 1:8.2, respectively, and for boiled meats 1:26.8.

These comparisons are also brought out in Tables 105 and 106.

TABLE 105.—*Chemical composition of cooked and uncooked meats* (*fresh substance*).

Kind of meat and method of cooking.	No. in average.	Water.	Proteid.			Organic extractives.		
			Insoluble.	Soluble.	Total.	Nitrogenous.	Non-nitrogenous.	Total.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Beef, raw	11	69.13	15.52	2.29	17.81	1.08	1.62	2.70
Veal, raw	2	75.75	16.23	2.37	18.60	1.17	1.66	2.83
Beef, boiled three hours	14	57.07	34.35	.26	34.61	.75	.88	1.63
Beef, boiled five hours	17	57.86	29.41	.47	29.88	.47	.65	1.12
Beef, boiled three and five hours	31	57.50	31.57	.38	31.95	.60	.75	1.35
Beef, pot roast	2	52.46	34.20	.37	34.57	1.26	1.43	2.69
Beef, roast	2	66.61	21.33	.99	22.32	1.15	1.41	2.56
Veal, roast	1	68.35	23.28	.41	23.69	1.34	1.89	3.23
Beef, gas broiled	1	66.26	21.95	.83	22.78	1.38	1.62	3.00
Beef, pan broiled	3	52.94	22.11	.74	22.85	1.34	1.59	2.93
Veal, pan broiled	1	65.33	26.29	.42	26.71	1.33	1.84	3.17
Beef, sautéed	2	65.34	21.76	.88	22.64	1.38	1.65	3.03
Beef, fried	1	57.78	27.06	.53	27.59	1.62	1.83	3.45

Kind of meat and method of cooking	Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Non-proteid nitrogen.	Ratio of nonproteid to proteid nitrogen.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Beef, raw	[a] 10.95	1.03	[a] 100.65	3.195	2.849	0.346	1: 8.3
Veal, raw	2.48	1.13	100.77	3.350	2.975	.375	1: 7.9
Beef, boiled three hours	6.49	.73	100.53	5.778	5.537	.241	1:23.0
Beef, boiled five hours	[b] 11.84	.60	[b] 100.87	4.932	4.782	.150	1:31.9
Beef, boiled three and five hours	[c] 9.34	.66	[c] 100.71	5.314	5.123	.191	1:26.8
Beef, pot roast	9.77	1.16	100.63	5.932	5.531	.401	1:13.8
Beef, roast	7.46	1.17	100.11	3.941	3.572	.369	1: 9.7
Veal, roast	4.65	1.36	101.28	4.220	3.791	.429	1: 8.8
Beef, gas broiled	7.64	1.22	100.90	4.088	3.645	.443	1: 8.2
Beef, pan broiled	20.47	1.20	100.39	4.086	3.657	.429	1: 8.5
Veal, pan broiled	5.20	1.44	101.85	4.700	4.274	.426	1:10.0
Beef, sautéed	8.11	1.18	100.29	4.064	3.622	.442	1: 8.2
Beef, fried	10.42	1.43	100.67	4.934	4.414	.520	1: 8.5

[a] Average of 10. [b] Average of 16. [c] Average of 30.

TABLE 106.—*Chemical composition of cooked and uncooked meats* (*water-free basis*).

Kind of meat and method of cooking.	No. in average.	Proteid.			Organic extractives.		
		Insoluble.	Soluble.	Total.	Nitrogenous.	Nonnitrogenous.	Total.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Beef, raw	11	54.45	8.14	62.59	3.83	5.78	9.61
Veal, raw	2	66.94	9.77	76.71	4.83	6.84	11.67
Beef, boiled three hours	14	80.06	.61	80.67	1.74	2.05	3.79
Beef, boiled five hours	17	72.95	1.16	74.11	1.18	1.66	2.84
Beef, boiled three and five hours	31	79.16	.91	77.07	1.43	1.84	3.27
Beef, pot roast	2	73.35	.77	74.12	2.47	2.83	5.30
Beef, roast	2	64.22	3.01	67.23	3.42	4.21	7.63
Veal, roast	1	73.55	1.30	74.85	4.23	5.97	10.20
Beef, gas broiled	1	65.06	2.46	67.52	4.09	4.80	8.89
Beef, pan broiled	3	53.56	2.02	55.58	3.35	3.95	7.30
Veal, pan broiled	1	75.83	1.21	77.04	3.84	5.31	9.15
Beef, sautéed	2	62.90	2.53	65.43	3.98	4.77	8.75
Beef, fried	1	64.09	1.26	65.35	3.84	4.33	8.17

TABLE 106.—*Chemical composition of cooked and uncooked meats (water-free basis)*—Continued.

Kind of meat and method of cooking.	Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Nonproteid nitrogen.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Beef, raw	[a]30.54	3.59	[a]102.27	11.244	10.014	1.230
Veal, raw	10.15	4.65	103.16	13.820	12.273	1.547
Beef, boiled three hours	15.08	1.69	101.22	13.466	12.906	.560
Beef, boiled five hours	[b]24.63	1.52	[b]102.30	12.234	11.857	.377
Beef, boiled three and five hours	[c]20.17	1.60	[c]101.80	12.790	12.331	.459
Beef, pot roast	19.75	2.34	101.48	12.476	11.634	.842
Beef, roast	22.06	3.50	100.41	11.851	10.756	1.098
Veal, roast	14.69	4.30	104.01	13.333	11.976	1.357
Beef, gas broiled	22.64	3.62	102.67	12.116	10.803	1.313
Beef, pan broiled	35.38	2.90	101.16	9.967	8.893	1.075
Veal, pan broiled	15.00	4.15	105.34	13.556	12.326	1.230
Beef, sautéed	23.24	3.40	100.81	11.744	10.469	1.275
Beef, fried	24.68	3.39	100.59	11.687	10.456	1.231

[a] Average of 10. [b] Average of 16. [c] Average of 30.

SOLUBILITY OF UNCOOKED AND COOKED MEATS IN COLD WATER.

Previous investigations have shown that a study of the solubility in cold water of meats before and after cooking is of value in determining the nature of the chemical changes which meats undergo during the processes of cooking. Furthermore, it seems more than probable, especially in the light of Armsby's recent experiments on the expenditure of energy in digestion and assimilation,[a] that a study of the solubility of meats in cold water would throw some light upon their real nutritive value and upon the ease and rapidity of their digestion and assimilation, since experimental data indicate clearly that, other conditions being the same, the easily soluble nutrients of foods are masticated, digested, and assimilated by the animal body with the expenditure of less energy than are the less soluble or the insoluble nutrients. Again, though the amount of fat present has a decided effect, the flavor of meats and of other foods also is undoubtedly due chiefly to the soluble constituents present; that is to say, the substances which give flavor to meats will be found in the cold-water extracts.

The statements are in accord with Rubner's[b] conclusions. He says in effect that the tenderer the meat the more easily are the flesh bases extracted by the saliva, and, other things being equal, the more pronounced is the pleasant flavor. He further maintains that the quality of meat also depends upon the kind and amount of the flesh bases. The character of the feed the animals have received has an effect upon flavor and quality, as do also age and sex.

In discussing the results of the study of the hemoglobin content of muscular tissue Lehmann and associates[a] point out that generally, though not always, other soluble constituents are present in abundance when the hemoglobin content is high. In other words, the red meats usually contain the largest amount of extractives and hence have the most pronounced flavor (exclusive of that due to fat). Although other factors undoubtedly exert more or less influence upon it, the hemoglobin content is very largely determined by exercise. In birds the much used muscles contain about three times as much as do those which are little used. In game the hemoglobin content is very high. The flesh of young animals contains less hemoglobin than that of old animals owing to the fact that the muscles have been little used. Since the amount of other extractives is usually directly proportional to the hemoglobin content, it is obvious that exercise and other factors which influence the amount of blood present in the muscular tissue may affect the flavor of meat very materially.

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[a] Armsby, Principles of Animal Nutrition, 1904, p. 372.

[b] E. von Leyden. Handbuch der Ernährungstherapie. Leipsic, 1903. 2. ed., p. 86.

Flavor—that is, the kind and amount of soluble bodies present in meat—is known to be influenced by hanging and storing. If putrefactive changes are not prevented amin bodies and later other compounds of very pronounced odor and flavor are produced, as was pointed out by C. Mai[b] in a study of meat putrefaction. Cold storage checks the action of putrefactive bacteria, but not that of the enzyms normally present in meat. The decided changes in flavor and texture which are noted when meat ripens in cold storage and which are entirely different from putrefactive changes are attributed to the continued action of these unorganized ferments. Meat which has hung for a time is generally considered of better flavor than that which is freshly killed. According to M. Müller,[c] who has studied the changes brought about by enzyms, meat held in cold storage is especially satisfactory for roasting or broiling, but from the standpoint of flavor of both meat and broth is not as good as freshly slaughtered meat for boiling.

In view of these considerations it is evident that more information regarding the quantities and the nature and character of the materials extracted from uncooked and cooked meats is highly desirable.

COMPOSITION OF THE COLD-WATER EXTRACTS OF UNCOOKED MEATS.

The quantity and the nature of the substances extracted from meats by either cold or hot water has apparently been studied but little. As far back as 1847 Justus Liebig,[d] in his classical research on the nature of the constituents of meat juice, determined in one or two instances the total quantity of beef and chicken flesh which was soluble in cold and in hot water. With beef flesh he obtained the following results: Material soluble in cold water, 6 per cent; material other than fat, insoluble in cold water, 17 per cent; fat, 2 per cent, and water, 75 per cent. Of the 6 per cent of material soluble in water, 2.95 per cent was coagulated by heat, the balance, 3.05 per cent, remaining in solution in hot water. Of the 17 per cent of insoluble material other than fat, 0.6 per cent was gelatinoids, since it was made soluble by boiling with water. In the case of chicken flesh, 8 per cent of material soluble in cold water was found, of which 4.70 per cent was coagulated by heat and 3.30 per cent remained dissolved in the hot water.

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[a] Ztschr. Biol., 45 (1903), p. 324.

[b] Ztschr. Untersuch. Nahr. u. Genussmtl., 4 (1901), p. 18.

[c] Arch. Hyg., 47 (1903), p. 127.

[d] Liebig's Ann. Chem., 62 (1847), p. 257.

Other investigators, about the time of Liebig or soon after, made cold-water extracts of different kinds of flesh mainly with a view to securing material for detailed analysis by the ordinary method; but, while the results of their complete analyses are on record,[a] we have not as yet found a description of the methods which they employed, nor have we found the results of their direct analyses of the water extracts. In view of these facts, it does not seem necessary to consider their work further in this connection.

There have been in later years, however, a number of investigations which should be referred to, namely, those of Almen,[b] Atwater and associates,[c] Henneberg and associates,[d] Wiley and associates,[e] and Gautier,[f] which are also mentioned on page 96 in connection with the discussion of the results of the chemical composition of uncooked and cooked meats.

In his study of fish, Almen prepared a cold-water extract of the flesh, and determined the albumin by coagulation by heat in the presence of a few drops of acetic acid, and the extractives by evaporating the water extract to dryness and weighing after removing the coagulated proteid. This residue was then ignited in order to determine the amount of soluble ash, which was subtracted from the total weight of the residue, the remainder being designated "extractives." Referring to the data on pages 98 and 99, it will be seen that the extractives as obtained by Almen's method correspond to the sum of the nitrogenous and nonnitrogenous extractives and the albumoses as obtained by the method used in the present investigations. Almen also determined the gelatinoids in the flesh of fish by treating the residue insoluble in cold water with boiling water for twelve hours. The resulting solution was evaporated to constant weight and calculated as gelatinoids. After deducting the fat and insoluble ash, the residue left after treatment with hot water was designated "insoluble proteid" (Fleischfaser).

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[a] Fremy, Encyclopedie Chimique, vol. 9, p. 467.

[b] Analyse der Fleisches einiger Fische. Upsala, 1877.

[c] U. S. Fish Commission Rpt. 1880, p. 231.

[d] Jour. Landw. (1878), p. 549.

[e] U. S. Dept. Agr., Bureau of Chemistry Bul. 53.

[f] Rev. Hyg. et Pol. Sanit., 19 (1897), p. 394.

Atwater and his associates, in their study of the chemical composition of fish flesh, determined the ingredients soluble in cold and in hot water in a number of samples. They prepared the extract by digesting 33.33 grams of the freshly chopped flesh eighteen to twenty-four hours in 500 cubic centimeters of cold water and then filtered it. The soluble albumin was determined by heating the cold-water extract to coagulation, filtering, washing with water and ether, drying, and weighing. The total amount of matter other than coagulable proteid dissolved by the cold water was determined by evaporating to dryness measured quantities of the filtrate from the coagulable proteid and weighing. One sample of the dry residue was used for the determination of the ash, and another finely ground was used for the estimation of fat. The total quantity of ash and fat thus obtained was subtracted from the crude extract in order to get the true extract, which was designated "extractive matters." The same investigators also determined the gelatinoids in fish flesh by treating the residue, insoluble in cold water, with boiling water for about twenty hours. The resulting solution was then filtered, the filtrate evaporated to dryness, and weighed as crude gelatin. In this fat and ash were determined and the pure gelatin was estimated by deducting the quantities of ash and fat from the crude residue left upon evaporation. The methods used by Atwater and coworkers are quite similar to those used by Almen, but it is apparent from the records available that in the American work greater precautions were taken with certain determinations to get concordant and accurate results.

Henneberg, Kern, and Wattenberg, in their investigation of the chemical composition of mutton, determined the extractives by the following method: Fifty grams of the fresh flesh were repeatedly treated with small quantities of cold water until the volume of the resulting filtrates measured 1,000 cubic centimeters. Portions of this filtrate were used for the estimation of ash, total dissolved matter, total nitrogen, and nitrogen in the solution after removing the coagulated albumin. The proteid nitrogen—i. e., that coagulated by heat—was also determined by difference. For purposes of comparison or as a test of the accuracy of the work, the proteid coagulated by heat was also removed, dried, and weighed. The figures for nonproteid nitrogen were multiplied by the factor 6.25 in order to get the amount of the so-called nonproteid extractives. The results obtained by Henneberg and associates with mutton flesh are comparable with those of Atwater and Almen with fish flesh.

Stated briefly, the methods used by Wiley and associates were as follows: The fresh meat was air-dried at a temperature of 100° C. or slightly higher, until the fat had very largely separated. The fat was poured off and the drying continued until the weight became approximately constant, when the residues thus obtained were extracted with ether to remove any remaining fat. The extracted flesh was dried to approximately constant weight and then left exposed to the air for at least twenty-four hours and again weighed. One-gram portions of the air-dried sample thus prepared were washed with ether, and after the ether had been allowed to evaporate were treated repeatedly with small quantities of water until 300 to 400 cubic centimeters had been used. The nitrogen in the insoluble residues was determined by the Kjeldahl method. The filtrates from the insoluble portions of the meat were placed in Kjeldahl flasks and used for the determination of the material precipitated by bromin (gelatinoids). The nitrogen in the bromin precipitates was determined by the Kjeldahl method. The percentage of nitrogen in the form of nitrogenous extractives (flesh bases) was found by subtracting the sum of the figures representing insoluble nitrogen and nitrogen precipitated by bromin, from the figures for total nitrogen. In calculating the percentage of flesh bases, the factor 3.12 was used, and for the other forms of nitrogen, the factor 6.25. It is evident from this outline that the results obtained are not directly comparable with those of the other investigations here mentioned, since air-dried samples of flesh were used, and there is much evidence to show that in the preparation of such samples, fresh meats undoubtedly undergo various fundamental chemical changes.

Notwithstanding the fact that so far we have not been able to learn the methods used by Gautier in his investigations with meats, his results are of decided interest, and the values which he reports for the composition of meat are summarized, with the data of the other investigators referred to, in the following table:

TABLE 107.—*Summary of analyses of cold-water extracts of meats.*

Kind of meat.	No. of analyses.	Proteid.	Organic extractives.			Fat.	Ash.	Total solid matter.	Nitrogen.			Ratio of nonproteid to proteid nitrogen.
			Nitrogenous.	Nonnitrogenous.	Total.				Total.	Proteid.	Nonproteid.	
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
Fish (fresh), Almen	8	2.49	......	......	1.93	......	......	......	......	......	......	......
Fish (salt), Almen	5	1.46	......	......	3.56	......	......	......	......	......	......	......
Fish (fresh), Atwater	24	1.55	......	......	1.95	......	......	......	......	......	......	......
Fish (cured), Atwater	7	.61	......	......	3.66	......	......	......	......	......	......	......
Mutton (fresh)[a], Henneberg	14	1.61	......	......	2.18	......	1.21	5.00	0.589	0.258	0.331	1:0.78
Pork (air-dried)[b], Wiley	88	......	1.14	......	......	......	......	......	.541	.176	.365	1: .48
Beef (fresh), Gautier	1	3.06	2.24	0.97	3.21	0	.65	6.92	......	......	......	......
Mutton (fresh), Gautier	1	3.32	1.33	.59	1.92	0	.60	5.84	......	......	......	......

[a] Results calculated to fat-free substance.
[b] The samples were air-dried before analysis, but the results have been calculated to fresh substance.

From the above summary it is apparent that the present knowledge of the cold-water extracts of various kinds of meats is very incomplete. The results of Gautier are the most detailed of those which have been found on record, although even here it is impossible to calculate the proteid and nonproteid nitrogen from his published results. Further, the values for the nonnitrogenous organic extractives as presented in the above table are not altogether satisfactory, since it was necessary for the authors of this bulletin to recalculate and readjust Gautier's published results in order to include them in the tabular comparison. This could not be done with assured accuracy without a knowledge of the analytical methods which he employed.

A number of investigators have reported studies of special groups of meat extractives, such as xanthin and other purin bodies, which should be referred to in this connection. I. W. Hall [a] has summarized the work of earlier investigators on purin bodies and reported the results of a number of original investigations. His recently published volume includes an extended bibliography.

The numerous investigations which have been made of the composition of commercial meat extract have a direct bearing on the question of soluble constituents of meat, but it does not necessarily follow that all constituents found in the extract existed in the muscular tissue, since some may be cleavage products formed when the meat juice was evaporated.

In a recently published study of meat extract, F. Kutscher [b] reports methylguanidin and a number of hitherto unknown nitrogenous bodies. It is undoubtedly true that such bodies, if they exist in the muscular tissue, are present in very small amounts; however, the results of this and other recently published works of a similar nature should be taken into account in future investigations.

In this summary no reference has been made to the numerous investigations which have been reported on the amount and proportion of glycogen and other carbohydrate constituents of flesh, as attention was directed especially to the nitrogenous bodies which exist in meat.

In the present investigation, detailed studies were made of the cold-water extracts of meat, and the data obtained are summarized in the following pages. Tables Nos. 108–113 show the total amount of soluble material in the raw and cooked meats, as well as the kind and cut of meat, the method of cooking, and the chemical nature of the material dissolved by cold water.

In Tables 108 and 109 data are summarized regarding the composition of the cold-water extracts of different kinds and cuts of raw meat.

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[a] The Purin Bodies of Food Stuffs. Philadelphia, 1904, 2. ed.

[b] Ztschr. Untersuch. Nahr. u. Genussmtl., 10 (1905), p. 528.

Table 108.—*Chemical composition of the cold-water extracts of raw meats, expressed in terms of the total weight of meat taken.*

Cooking experiment No.	Laboratory No.	Kind of meat.	Proteid.	Organic extractives.			Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Non-proteid nitrogen.	Ratio of non-proteid to proteid nitrogen.
				Nitrogenous.	Non-nitrogenous.	Total.							
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
122	1672	Beef, flank, raw....	1.21	0.77	0.96	1.73	0	0.55	3.49	0.440	0.194	0.246	1:0.79
121	1668	Beef, neck, raw	2.30	.81	1.63	2.44	0	.77	5.51	.627	.368	.259	1:1.42
107	1637	Beef, round, raw...	2.76	1.08	2.22	3.30	0	.98	7.04	.790	.442	.348	1:1.27
108–109	1640	.....do	2.77	1.37	1.72	3.09	0	.98	6.84	.883	.443	.440	1:1.01
110–113	1647	.....do	1.82	1.41	1.95	3.36	0	.91	6.12	.744	.292	.452	1: .65
131–132	1722	.....do	2.70	1.12	1.99	3.11	0	.89	6.70	.791	.432	.359	1:1.21
133–136	1741	.....do	2.80	1.24	1.78	3.02	0	.89	6.71	.846	.418	.398	1:1.13
137–140	1753	.....do	2.39	1.11	1.52	2.63	0	.92	5.94	.739	.383	.356	1:1.08
141–147	1764	.....do	2.70	1.18	1.73	2.91	0	.73	6.34	.811	.433	.378	1:1.15
150–156	1775	.....do	2.20	1.13	1.40	2.53	0	.87	5.60	.714	.352	.362	1: .97
		Average Nos. 1637, 1640, 1647, 1722, 1741, 1753, 1764, and 1775	2.52	1.21	1.79	3.00	0	.90	6.42	.790	.403	.387	1:1.04
123–124	1676	Beef, rump, raw....	1.54	.66	.88	1.54	0	.61	3.69	.456	.246	.210	1:1.17
		Average of all beef samples	2.29	1.08	1.62	2.70	0	.83	5.82	.713	.367	.346	1:1.06
114–116	1656	Veal, leg, raw	2.83	1.26	1.94	3.20	0	1.00	7.03	.855	.452	.403	1:1.12
117–120	1662	.....do	1.90	1.08	1.37	2.45	0	.91	5.26	.650	.303	.347	1: .87
		Average	2.37	1.17	1.66	2.83	0	.95	6.15	.753	.378	.375	1:1.01
		Average of all beef and veal samples.............	2.30	1.09	1.63	2.72	0	.85	5.87	.719	.369	.350	1:1.05

Table 109.—*Chemical composition of cold-water extracts of meats (water-free basis).*

Cooking experiment No.	Laboratory No.	Kind of meat.	Proteid.	Organic extractives.			Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Non-protied nitrogen.
				Nitrogenous.	Non-nitrogenous.	Total.						
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
122	1672	Beef, flank, raw	2.99	1.89	2.35	4.24	0	1.35	8.58	1.078	0.478	0.600
121	1668	Beef, neck, raw.....	8.02	2.82	5.68	8.50	0	2.68	19.20	2.183	1.283	.900
107	1637	Beef, round, raw....	11.27	4.41	9.07	13.48	0	4.00	28.75	3.229	1.803	1.426
108–109	1640	.....do................	10.68	5.28	6.62	11.90	0	3.77	26.35	3.401	1.709	1.692
110–113	1647	.....do................	7.05	5.46	7.55	13.01	0	3.64	23.70	2.881	1.128	1.753
131–132	1722	.....do................	9.86	4.08	7.25	11.33	0	3.25	24.41	2.885	1.578	1.307
133–136	1741	.....do................	10.15	4.50	6.46	10.96	0	3.23	24.34	3.071	1.624	1.447
137–140	1753	.....do................	9.09	4.21	5.77	9.98	0	3.47	22.54	2.805	1.454	1.351
141–147	1764	.....do................	9.00	3.92	5.75	9.67	0	2.44	21.11	2.695	1.440	1.255
150–156	1775	.....do................	8.23	4.23	5.24	9.47	0	3.26	20.96	2.673	1.317	1.356
		Average Nos. 1637, 1640, 1647, 1722, 1741, 1753, 1764, and 1765	9.42	4.51	6.71	11.22	0	3.38	24.02	2.955	1.507	1.448
123–124	1676	Beef, rump, raw	3.23	1.38	1.84	3.22	0	1.28	7.73	.955	.517	.438
		Average of all beef samples.........	8.14	3.83	5.78	9.61	0	2.94	20.69	2.532	1.303	1.229
114–116	1656	Veal, leg, raw.......	11.78	5.24	8.07	13.31	0	4.16	29.25	3.558	1.885	1.673
117–120	1662	.....do................	7.76	4.41	5.60	10.01	0	3.72	21.49	2.658	1.242	1.416
		Average	9.77	4.83	6.84	11.67	0	3.94	25.38	3.108	1.564	1.544
		Average of all beef and veal samples............	8.39	3.98	5.94	9.92	0	3.09	21.41	2.621	1.343	1.278

The data presented show that a considerable proportion of raw flesh is soluble in cold water. In the case of 11 samples of beef flesh, the extracted material contained on an average 2.29 per cent proteid, 1.08 per cent flesh bases (nitrogenous organic extractives), 1.62 per cent nonnitrogenous organic extractives, 2.70 per cent total organic extractives, and 0.83 per cent ash, making a total of 5.82 per cent soluble matter. The total nitrogen dissolved by cold water averaged 0.713 per cent, and of this total nitrogen 0.367 per cent existed in the form of proteid and 0.346 per cent as nonproteid nitrogen. The ratio of nonproteid nitrogen to proteid nitrogen was 1:1.06.

In the case of two samples of veal the cold-water extract contained on an average 2.37 per cent proteid, 1.17 per cent flesh bases, 1.66 per cent nonnitrogenous organic extractives, 2.83 per cent total organic extractives, and 0.95 per cent ash, giving a total of 6.15 per cent soluble material. The total nitrogen dissolved by cold water averaged 0.753 per cent, of which 0.378 per cent existed as proteid and 0.375 per cent as nonproteid nitrogen. The ratio of the nonproteid to the proteid nitrogen was 1:1.01.

By comparing the data here presented regarding each individual nutrient with the results of the complete analysis of the meat as given in Tables 98 and 99 (pp. 99, 100), it will be observed that 8.67 to 15.03 per cent of the total proteid in the beef was soluble in water, the average for the 11 samples of raw beef being 12.86 per cent and for the 2 samples of veal a somewhat greater proportion. All of the nitrogenous and nonnitrogenous extractives were found to be soluble, while none of the fat of the flesh went into solution in cold water. The greater part of the ash was extracted, the average in the case of beef being 80.58 per cent, and in the case of veal 84.96 per cent.

The total nutrients soluble in cold water, expressed as per cent of the total nutrients in the original meat (see p. 99), varies from 7.63 in beef rump (sample No. 1676) to 28.71 per cent in veal leg (sample No. 1656), the average for beef being 18.46 and for veal 24.54 per cent. In other words, these experiments indicate that from one-fifth to one-fourth of the total nutrients of raw beef and veal are soluble in cold water.

The average results of the experiments here reported also show that the solid matter obtained by treating beef flesh with cold water contains 12.25 per cent nitrogen, 39.34 per cent proteid, 18.56 per cent nitrogenous organic extractives, 27.84 per cent nonnitrogenous organic extractives, and 14.26 per cent ash, but no fat. Judging from the data obtained with two samples, the cold-water extract of veal contains 12.27 per cent nitrogen, 38.60 per cent proteid, 20.36 per cent nitrogenous organic extractives, 25.73 per cent nonnitrogenous organic extractives, and 15.63 per cent ash.

It is evident that the nitrogen existing in the cold-water extracts of raw meats is quite equally divided between proteid and nonproteid substances, the average ratio for 13 samples of beef and veal being 1:1.05.

COMPOSITION OF THE COLD-WATER EXTRACTS OF MEATS COOKED BY BOILING.

The tables which follow summarize data regarding the composition of cold-water extracts of boiled meat.

TABLE 110.—*Chemical composition of cold-water extracts of meats cooked by boiling (fresh substance).*

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Proteid.	Organic extractives.		
				At beginning.	During cooking.			Nitrogenous.	Non-nitrogenous.	Total.
				°C.	*°C.*	*Hours.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1642	1640	109	Beef, round	Cold.	85	3	0.13	0.43	0.56	0.99
1754	1753	137	.....do	Cold.	85	3	.20	.78	.82	1.60
			Average	Cold.	85	3	.17	.61	.69	1.30
1756	1753	139	Beef, round (browned)	Cold.	85	3	.17	.75	.75	1.50
			Average Nos. 1642, 1754, and 1756	Cold.	85	3	.17	.65	.71	1.36
1746	1741	136	Beef, round (browned)	85	85	3	.15	.73	.91	1.64
1769	1764	145	Beef, round	85	85	3	.21	.95	.88	1.83
1780	1775	154	.....do	85	85	3	.13	.80	.92	1.72
			Average Nos. 1769 and 1780	85	85	3	.17	.88	.90	1.78
			Average Nos. 1746, 1769, and 1780	85	85	3	.16	.83	.90	1.73
1641	1640	108	Beef, round	100	85	3	.38	.33	.45	.78
1744	1741	134	.....do	100	85	3	.33	.79	1.08	1.87
1768	1764	144	.....do	100	85	3	.21	.99	1.28	2.27
1779	1775	153	.....do	100	85	3	.20	.94	1.04	1.98
			Average	100	85	3	.28	.76	.96	1.72
1755	1753	138	Beef, round	Cold.	100	3	.44	.74	.90	1.64
1757	1753	140	Beef, round (browned)	Cold.	100	3	.49	.79	.91	1.70
			Average	Cold.	100	3	.47	.77	.90	1.67
1743	1741	133	Beef, round	100	100	3	.33	.77	1.04	1.81
1745	1741	135	Beef, round (browned)	100	100	3	.24	.72	.79	1.51
			Average	100	100	3	.29	.75	.91	1.66
			Average of all cooked 3 hours	....	....	3	.26	.75	.88	1.63
1646	1647	113	Beef, round	Cold.	65	5	.27	.29	.38	.67
1645	1647	112	.....do	Cold.	85	5	.36	.32	.43	.75
1654	1656	116	Veal, leg	Cold.	85	5	.60	.29	.96	1.25
1658	1662	118	.....do	Cold.	85	5	.31	.44	.55	.99
			Average Nos. 1654 and 1658	Cold.	85	5	.46	.37	.75	1.12
			Average Nos. 1645, 1654, and 1658	Cold.	85	5	.42	.35	.65	1.00

TABLE 110.—*Chemical composition of cold-water extracts of meats cooked by boiling (fresh substance)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Proteid.	Organic extractives.		
				At beginning.	During cooking.			Nitrogenous.	Non-nitrogenous.	Total.
				°C.	°C.	*Hours.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1644	1647	111	Beef, round	100	85	5	0.29	0.40	0.57	0.97
1720	1722	131	.....do	100	85	5	.16	.65	.15	.80
			Average	100	85	5	.23	.53	.36	.89
1665	1668	121	Beef, neck	100	85	5	.19	.32	.55	.87
1673	1676	123	Beef, rump	100	85	5	.38	.47	.43	.90
1703	1705	125	.....do	100	85	5	.38	.29	.34	.63
			Average Nos. 1673 and 1703	100	85	5	.38	.38	.39	.77
1669	1672	122	Beef, flank	100	85	5	.39	.04	.17	.21
1653	1656	115	Veal, leg	100	85	5	.49	.69	1.00	1.69
1664	1662	117	.....do	100	85	5	.32	.55	.77	1.32
			Average Nos. 1653 and 1664	100	85	5	.41	.62	.89	1.51
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1708, and 1720	100	85	5	.33	.43	.50	.93
1639	1637	107	Beef, round	100	100	5	.97	.48	1.19	1.67
1643	1647	110	.....do	100	100	5	.92	.44	.57	1.01
1721	1722	132	.....do	100	100	5	.56	.65	.50	1.15
			Average	100	100	5	.82	.52	.75	1.27
1704	1705	126	Beef, rump	100	100	5	.90	.53	.72	1.25
1652	1656	114	Veal, leg	100	100	5	.44	1.12	1.67	2.79
			Average Nos. 1639, 1643, 1652, 1704, and 1721	100	100	5	.76	.64	.93	1.57
			Average of all cooked 5 hours				.47	.47	.65	1.12
			Average of all cooked 3 or 5 hours				.38	.60	.75	1.35

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Non-proteid nitrogen.	Ratio of non-proteid to proteid nitrogen.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
1642	1640	109	Beef, round	0	0.27	1.39	0.160	0.021	0.139	1:0.15
1754	1753	137	.....do	0	.55	2.35	.282	.032	.251	1: .13
			Average	0	.41	1.88	.221	.027	.194	1: .14
1756	1753	139	Beef, round (browned)	0	.50	2.17	.268	.028	.240	1: .12
			Average Nos. 1642, 1754, and 1756	0	.44	1.97	.237	.027	.210	1: .13
1746	1741	136	Beef, round (browned)	0	.51	2.30	.260	.024	.236	1: .18
1769	1764	145	Beef, round	0	.63	2.67	.339	.035	.304	1: .10
1780	1775	154	.....do	0	.57	2.42	.276	.021	.255	1: .01
			Average Nos. 1769 and 1780	0	.60	2.55	.308	.028	.280	1: .10
			Average Nos. 1746, 1769, and 1780	0	.57	2.46	.292	.026	.266	1: .10

Table 110.—*Chemical composition of cold-water extracts of meats cooked by boiling (fresh substance)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Non-proteid nitrogen.	Ratio of non-proteid to proteid nitrogen.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
1641	1640	108	Beef, round	0	0.29	1.45	0.168	0.062	0.106	1:0.58
1741	1741	134	.....do	0	.53	2.73	.307	.052	.255	1: .20
1768	1764	144	.....do	0	.32	2.80	.352	.034	.318	1: .11
1779	1775	153	.....do	0	.60	2.78	.332	.032	.300	1: .11
			Average	0	.44	2.44	.290	.045	.245	1: .18
1755	1753	138	Beef, round	0	.42	2.50	.309	.070	.239	1: .29
1757	1753	140	Beef, round (browned)	0	.52	2.71	.332	.078	.254	1: .31
			Average	0	.47	2.61	.321	.074	.247	1: .30
1743	1741	133	Beef, round	0	.57	2.71	.300	.053	.247	1: .21
1745	1741	135	Beef, round (browned)	0	.51	2.26	.270	.039	.231	1: .17
			Average	0	.54	2.49	.285	.046	.239	1: .19
			Average of all cooked 3 hours	0	.49	2.38	.283	.042	.241	1: .17
1646	1647	113	Beef, round	0	.24	1.18	.138	.044	.094	1: .47
1615	1647	112	.....do	0	.34	1.45	.161	.057	.104	1: .55
1654	1656	116	Veal, leg	0	.50	2.35	.189	.095	.094	1:1.01
1658	1662	118	.....do	0	.40	1.70	.190	.050	.140	1: .36
			Average Nos. 1654 and 1658	0	.45	2.03	.190	.073	.117	1: .62
			Average Nos. 1645, 1654, and 1658	0	.41	1.83	.180	.067	.113	1; .60
1641	1647	111	Beef, round	0	.38	1.64	.174	.046	.128	1: .36
1720	1722	131	.....do	0	.25	1.21	.234	.026	.208	1: .13
			Average	0	.31	1.43	.204	.036	.168	1: .21
1665	1668	121	Beef, neck	0	.20	1.26	.132	.030	.102	1: .29
1673	1676	123	Beef, rump	0	.25	1.53	.212	.061	.151	1: .40
1703	1705	125	.....do	0	.28	1.29	.154	.061	.093	1: .66
			Average Nos. 1673 and 1703	0	.26	1.41	.183	.061	.122	1: .50
1669	1672	122	Beef, flank	0	.20	.80	.077	.063	.014	1:4.50
1653	1656	115	Veal, leg	0	.60	2.78	.301	.079	.222	1: .36
1664	1662	117	.....do	0	.53	2.17	.227	.052	.175	1: .30
			Average Nos. 1653 and 1664	0	.56	2.48	.264	.066	.198	1: .33
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	0	.34	1.60	.189	.052	.137	1: .38
1639	1637	107	Beef, round	0	.50	3.14	.309	.155	.154	1:1.01
1643	1647	110	.....do	0	.44	2.37	.288	.147	.141	1:1.04
1721	1722	132	.....do	0	.38	2.09	.297	.089	.208	1: .43
			Average	0	.44	2.53	.298	.130	.168	1: .77
1704	1705	126	Beef, rump	0	.47	2.62	.315	.144	.171	1: .84
1652	1656	114	Veal, leg	0	.73	3.96	.428	.070	.358	1: .20
			Average Nos. 1639, 1643, 1652, 1704, and 1721	0	.50	2.83	.327	.121	.206	1: .59
			Average of all cooked 5 hours	0	.39	1.98	.225	.074	.151	1: .49
			Average of all cooked 3 or 5 hours	0	.44	2.17	.251	.060	.191	1: .31

TABLE 111.—*Chemical composition of cold-water extracts of meats cooked by boiling (water-free substance).*

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Proteid.	Organic extractives.	
				At beginning.	During cooking.			Nitrogenous.	Nonnitrogenous.
				°*C.*	°*C.*	*Hours.*	*Per ct.*	*Per ct.*	*Per ct.*
1642	1640	109	Beef, round	Cold.	85	3	0.35	1.07	1.40
1754	1753	137	do	Cold.	85	3	.46	1.78	1.87
			Average				.40	1.43	1.64
1756	1753	139	Beef, round (browned)	Cold.	85	3	.40	1.75	1.75
			Average Nos. 1642, 1754, and 1756				.40	1.53	1.67
1746	1741	136	Beef, round (browned)	85	85	3	.35	1.68	2.09
1769	1764	145	Beef, round	85	85	3	.50	2.18	2.02
1780	1775	154	do	85	85	3	.29	1.79	2.05
			Average Nos. 1769 and 1780				.40	1.99	2.04
			Average Nos. 1746, 1769, and 1780				.38	1.88	2.05
1641	1640	108	Beef, round	100	85	3	.93	.81	1.10
1744	1741	134	do	100	85	3	.78	1.88	2.56
1768	1764	144	do	100	85	3	.51	2.40	3.11
1779	1775	153	do	100	85	3	.44	2.05	2.27
			Average				.67	1.79	2.26
1755	1753	138	Beef, round	Cold.	100	3	1.00	1.69	2.06
1757	1753	140	Beef, round (browned)	Cold.	100	3	1.13	1.81	2.09
			Average				1.07	1.75	2.08
1743	1741	133	Beef, round	100	100	3	.78	1.82	2.46
1745	1741	135	Beef, round (browned)	100	100	3	.57	1.68	1.85
			Average				.68	1.75	2.16
			Average of all cooked 3 hours				.61	1.74	2.05
1646	1647	113	Beef, round	Cold.	65	5	.73	.78	1.03
1645	1647	112	do	Cold.	85	5	.89	.80	1.07
1654	1656	116	Veal, leg	Cold.	85	5	1.89	.92	3.06
1658	1662	118	do	Cold.	85	5	.91	1.25	1.55
			Average				1.40	1.09	2.31
			Average Nos. 1645, 1654, and 1658				1.23	.99	1.89
1644	1647	111	Beef, round	100	85	5	.71	.98	1.39
1720	1722	131	do	100	85	5	.36	1.45	.34
			Average				.54	1.22	.87
1665	1668	121	Beef, neck	100	85	5	.42	.70	1.21
1673	1676	123	Beef, rump	100	85	5	.62	.76	.70
1703	1705	125	do	100	85	5	.74	.56	.66
			Average Nos. 1673 and 1703				.68	.66	.68
1669	1672	122	Beef, flank	100	85	5	.75	.07	.32
1653	1656	115	Veal, leg	100	85	5	1.47	2.07	3.00
1664	1662	117	do	100	85	5	.84	1.47	1.99
			Average Nos. 1653 and 1664				1.16	1.77	2.50
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720				.74	1.01	1.20

TABLE 111.—*Chemical composition of cold-water extracts of meats cooked by boiling (water-free substance)*—Continued.

Laboratory No.	Raw meat used, No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Proteid.	Organic extractives.	
				At beginning.	During cooking.			Nitrogenous.	Nonnitrogenous.
				°C.	°C.	Hours.	Per ct.	Per ct.	Per ct.
1639	1637	107	Beef, round	100	100	5	2.40	1.19	2.95
1643	1647	110	.....do	100	100	5	2.33	1.12	1.44
1721	1722	132	.....do	100	100	5	1.31	1.51	1.17
			Average				2.01	1.27	1.85
1704	1705	126	Beef, rump	100	100	5	2.00	1.18	1.60
1652	1656	114	Veal, leg	100	100	5	1.25	3.18	4.74
			Average Nos. 1639, 1643, 1652, 1701, and 1721				1.86	1.63	2.38
			Average of all cooked 5 hours				1.16	1.18	1.66
			Average of all cooked 3 or 5 hours				.88	1.43	1.84

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Total extractives.	Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Nonproteid nitrogen.
				Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1642	1640	109	Beef, round	2.47	0	0.67	3.49	0.399	0.053	0.346
1754	1753	157	.....do	3.65	0	1.25	5.36	.645	.073	.572
			Average	3.07	0	.96	4.43	.522	.063	.459
1756	1753	139	Beef, round (browned)	3.50	0	1.16	5.06	.626	.065	.561
			Average Nos. 1612, 1754, and 1756	3.20	0	1.03	4.64	.557	.061	.493
1746	1741	136	Beef, round (browned)	3.77	0	1.17	5.29	.597	.055	.542
1769	1764	145	Beef, round	4.20	0	1.46	6.16	.779	.080	.699
1780	1775	154	.....do	3.84	0	1.27	5.40	.617	.046	.571
			Average Nos. 1769, and 1780	4.03	0	1.37	5.78	.698	.063	.635
			Average Nos. 1746, 1769, and 1780	3.93	0	1.30	5.62	.664	.060	.604
1641	1640	108	Beef, round	1.91	0	.71	3.55	.411	.150	.261
1744	1741	134	.....do	4.44	0	1.26	6.48	.728	.124	.604
1768	1764	144	.....do	5.51	0	.79	6.81	.855	.082	.773
1779	1775	153	.....do	4.32	0	1.31	6.07	.724	.070	.654
			Average	4.05	0	1.02	5.73	.680	.107	.573
1755	1753	138	Beef, round	3.75	0	.96	5.71	.706	.161	.545
1757	1753	140	Beef, round (browned)	3.90	0	1.20	6.23	.763	.180	.583
			Average	3.83	0	1.08	5.97	.735	.171	.564
1743	1741	133	Beef, round	4.28	0	1.35	6.41	.707	.124	.583
1745	1741	135	Beef, round (browned)	3.53	0	1.19	5.29	.631	.091	.540
			Average	3.91	0	1.27	5.85	.669	.108	.561
			Average of all cooked 3 hours	3.79	0	1.13	5.52	.657	.097	.560
1646	1647	113	Beef, round	1.81	0	.65	3.19	.372	.118	.254
1645	1647	112	.....do	1.87	0	.84	3.59	.401	.142	.259
1654	1656	116	Veal, leg	3.98	0	1.59	7.46	.602	.303	.299
1658	1662	118	.....do	2.80	0	1.13	4.84	.539	.142	.397
			Average	3.40	0	1.36	6.15	.571	.223	.348
			Average Nos. 1645, 1654, and 1658	2.88	0	1.19	5.30	.514	.196	.318

TABLE 111.—*Chemical composition of cold-water extracts of meats cooked by boiling (water-free substance)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Total extractives.	Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Nonproteid nitrogen.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1644	1647	111	Beef, round	2.37	0	0.93	4.01	0.426	0.113	0.313
1720	1722	131	.....do	1.79	0	.57	2.72	.524	.057	.467
			Average	2.09	0	.75	3.37	.475	.085	.390
1665	1668	121	Beef, neck	1.91	0	.44	2.77	.290	.066	.224
1673	1676	123	Beef, rump	1.46	0	.41	2.49	.343	.099	.244
1703	1705	125	.....do	1.22	0	.54	2.50	.297	.118	.179
			Average Nos. 1673 and 1703	1.34	0	.48	2.50	.320	.109	.211
1669	1672	122	Beef, flank	.39	0	.37	1.51	.144	.118	.026
1653	1656	115	Veal, leg	5.07	0	1.80	8.34	.903	.237	.666
1664	1662	117	.....do	3.46	0	1.39	5.69	.595	.135	.460
			Average Nos. 1653 and 1664	4.27	0	1.60	7.02	.749	.186	.563
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	2.21	0	.81	3.76	.440	.118	.322
1639	1637	107	Beef, round	4.14	0	1.24	7.78	.766	.384	.382
1643	1647	110	.....do	2.56	0	1.11	6.00	.730	.372	.358
1721	1722	132	.....do	2.68	0	.90	4.89	.694	.208	.486
			Average	3.12	0	1.08	6.22	.730	.321	.409
1704	1705	126	Beef, rump	2.78	0	1.04	5.82	.699	.320	.379
1652	1656	114	Veal, leg	7.92	0	2.07	11.24	1.215	.199	1.016
			Average Nos. 1639, 1643, 1652, 1704, and 1721	4.01	0	1.27	7.15	.821	.297	.524
			Average of all cooked 5 hours	2.84	0	1.00	5.00	.561	.184	.377
			Average of all cooked 3 or 5 hours	3.27	0	1.06	5.23	.604	.145	.459

The data reported show that the cold-water extract of 31 samples of boiled beef and veal contained on an average 0.38 per cent proteid, 0.60 per cent nitrogenous extractives, 0.75 per cent nonnitrogenous extractives, 1.35 per cent organic extractives, and 0.44 per cent of mineral matter, making a total of 2.17 per cent soluble matter. The total nitrogen averaged 0.251 per cent, of which 0.060 per cent existed as soluble proteid and 0.191 per cent as nonproteid nitrogen. The ratio of nonproteid to proteid nitrogen was 1:0.31. Comparison of these figures with those on page 127 indicate that boiled meat is by no means as soluble in cold water as raw. It must be remembered, however, that these figures for the solubility of uncooked and boiled meats as reported are not directly comparable, since the uncooked meats contain much more water than do the cooked meats. It will therefore be more satisfactory to consider the results as calculated to a water-free basis. When the results are thus stated (see Table 111, p. 132), we find that cold water removed from the 31 samples of boiled flesh on an average 0.88 per cent proteid, 1.43 per cent nitrogenous extractives, 1.84 per cent nonnitrogenous extractives, 3.27 per cent organic extractives, and 1.06 per cent ash, making in all 5.23 per cent soluble material. Upon the same basis, the amount of total nitrogen dissolved by cold water from the boiled meats averaged 0.604 per cent, of which 0.145 per cent existed as proteid and 0.459 per cent as nonproteid nitrogen.

In the case of raw meats the average values for samples on a water-free basis (see Table 109, p. 127) are: 8.39 per cent proteid, 3.98 per cent nitrogenous extractives, 5.94 per cent nonnitrogenous extractives, 9.92 per cent total organic extractives, 3.09 per cent ash, or 21.41 per cent total soluble matter. The average percentage of total nitrogen dissolved by cold water from the raw meats was 2.621, of which 1.343 existed as proteid nitrogen and 1.278 as nonproteid nitrogen.

These results show plainly that boiled meats are much less soluble in cold water than similar cuts of raw meat, the total nutrients of raw meats being 4.7 times more soluble in cold water than the nutrients of meats cooked in hot water. As regards the individual constituents, the proteids of raw meats are 9.5 times more soluble in cold water than are the proteids of boiled meats. The nitrogenous and nonnitrogenous extractives of both raw and cooked meats are completely soluble in water, but the cold-water extracts of uncooked meats contain three times as great a quantity of these substances as do the cold-water extracts of boiled meats, calculated to the water-free basis. The cold-water extracts of uncooked meats contain three times as much ash and 4.3 times more total nitrogen, 9.2 times more proteid nitrogen, and 2.8 times more nonproteid nitrogen than do cold-water extracts of meats cooked in hot water.

By comparing the data here presented regarding each individual nutrient in the cold-water extracts of meats cooked by boiling with the results of the complete analysis of the cooked meats as given in Table No. 100, it will be found that only 1.19 per cent of the total proteid existing in the cooked meat was soluble in cold water, while in the case of the raw meats 12.86 per cent of the total proteid was in a soluble form. As in the case of the uncooked meats, all of the nitrogenous and nonnitrogenous extractives of the boiled meats were found to be soluble, while none of the fat of the flesh entered into solution. A considerable proportion of the ash of the boiled meat was soluble in water, the average being 66.67 per cent as compared with 80.58 per cent for 11 samples of raw beef.

The total nutrients soluble in cold water, expressed as per cent of the total nutrients in the boiled meats, varies from 1.47 in beef flank (sample No. 1669) to 10.87 per cent in the case of veal leg (sample No. 1652), the average being 5.02 per cent. In other words, these experiments indicate that on an average one-twentieth of the total nutrients of the cooked meat are soluble in cold water. In the raw meats the total nutrients soluble in cold water form 18.46 per cent or about one-fifth of the total nutrients originally present.

The average results of the 31 analyses of the meats cooked in hot water indicate that the solid matter obtained by extraction with cold water contains 11.57 per cent nitrogen, 17.51 per cent proteid, 27.65 per cent nitrogenous extractives, 34.56 per cent nonnitrogenous extractives, and 20.28 per cent ash. The corresponding data for the raw meats were as follows: 12.25 per cent nitrogen, 39.34 per cent proteid, 18.56 per cent nitrogenous extractives, 27.84 per cent nonnitrogenous extractives, and 14.26 per cent ash.

In the case of boiled meat the soluble matter of the cold-water extract contains much less proteid matter and considerably greater quantities of nitrogenous and nonnitrogenous extractives and ash than in the case of raw meats.

It is evident from the data here given, that in the cold-water extracts of meats cooked in hot water, the proportion of proteid and the nonproteid nitrogen is quite unlike that in the cold-water extracts of uncooked meats. In the former the ratio of nonproteid to proteid nitrogen is 1:0.31 and in the latter 1:1.05.

In discussing the chemical composition of meats cooked by boiling (p. 113), the conclusion was reached that there were no marked or important differences in the chemical composition and nutritive value of meats which had been cooked in hot water by different methods. The data obtained in the study of the chemical composition of the cold-water extracts of the boiled meats furnish some additional information on this point, and the following table gives a summary of the averages of the results obtained in the analyses of the cold-water extracts of meats cooked in hot water by different methods:

TABLE 112.—*Summary showing the chemical composition of cold-water extracts of meats cooked by different methods of boiling.*

Method of cooking.	Average of.	Temperature.		Duration of cooking.	Proteid.	Organic extractives.			Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Nonproteid nitrogen.	Ratio of nonproteid to proteid nitrogen.
		At beginning.	During cooking.			Nitrogenous.	Nonnitrogenous.	Total.							
		°C.	°C.	Hrs.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	
Boiled	3	Cold.	85	3	0.17	0.65	0.71	1.36	0	0.44	1.97	0.237	0.027	0.210	1:0.13
Do	3	85	85	3	.16	.83	.90	1.73	0	.57	2.16	.292	.026	.266	1: .10
Do	4	100	85	3	.28	.76	.96	1.72	0	.44	2.44	.290	.045	.245	1: .18
Do	10	......	85	3	.21	.75	.87	1.62	0	.48	2.31	.275	.031	.241	1: .14
Do	2	Cold.	100	3	.47	.77	.90	1.67	0	.47	2.61	.321	.074	.247	1: .30
Do	2	100	100	3	.29	.75	.91	1.66	0	.54	2.49	.285	.046	.239	1: .19
Do	1	......	100	3	.38	.76	.91	1.67	0	.51	2.55	.303	.060	.243	1: .25
Boiled, 3 hours	14	......	......	3	.26	.75	.88	1.63	0	.49	2.38	.283	.042	.241	1: .17
Do	1	Cold.	65	5	.27	.29	.38	.67	0	.24	1.18	.138	.044	.094	1: .47
Do	3	Cold.	85	5	.42	.35	.65	1.00	0	.41	1.83	.180	.067	.113	1: .60
Do	8	100	85	5	.33	.43	.50	.93	0	.34	1.60	.189	.052	.137	1: .38
Do	11	......	85	5	.35	.41	.54	.95	0	.36	1.66	.187	.056	.131	1: .44
Do	5	100	100	5	.76	.64	.93	1.57	0	.50	2.83	.327	.121	.206	1: .59
Boiled, 5 hours	17	......	......	5	.47	.47	.65	1.12	0	.39	1.98	.225	.074	.151	1: .49
Boiled, 3 and 5 hours	31	......	......	.....	.38	.60	.75	1.35	0	.14	2.17	.251	.060	.191	1: .31
Uncooked	13	......	......	.....	2.30	10.9	1.63	2.72	0	.85	5.87	.719	.369	.350	1:1.05

It is evident from the data in Table 112, that the differences between the chemical composition of the cold-water extracts of meats cooked by different methods of boiling are much less than those which exist between boiled meats and raw meats. There appear to be, however, slight differences in the case of meats cooked for three and for five hours. The average composition of the cold-water extracts of 14 samples of meats cooked for three hours was 0.26 per cent proteid, 0.75 per cent nitrogenous extractives, 0.88 per cent nonnitrogenous extractives, 1.63 per cent total organic extractives, 0.49 per cent ash, and 2.38 per cent total soluble matter. The total nitrogen dissolved by cold water averaged 0.283 per cent, of which 0.042 per cent existed as proteid and 0.241 per cent as nonproteid nitrogen. The ratio of nonproteid to proteid nitrogen, was 1:0.17. The average composition of the cold-water extracts of the 17 samples of meats which had been cooked for five hours was as follows: 0.47 per cent proteid, 0.47 per cent nitrogenous extractives, 0.65 per cent nonnitrogenous extractives, 1.12 per cent total organic extractives, 0.39 per cent ash, and 1.98 per cent total soluble material. The total dissolved nitrogen averaged 0.225 per cent, of which 0.074 per cent was proteid and 0.151 per cent nonproteid nitrogen, the ratio of nonproteid to proteid nitrogen being 1:0.49. These results show that the meats cooked for the longer time in hot water contained almost twice as much soluble proteid, but only about two-thirds as much total organic extractives, and four-fifths as much ash and total soluble material as those cooked for the shorter period. The differences in the composition of the cold-water extracts of meats cooked at different temperatures are so slight (see Table 110) that it is not deemed necessary to consider them in detail here.

In conclusion it may be said that the analyses of the cold-water extracts of boiled meats confirm the deduction made from the data regarding their chemical composition, namely, that the different methods commonly used in cooking meats in hot water cause only slight variations in the composition and solubility, and hence in nutritive value and flavor of the resulting product.

Composition of the Cold-water Extracts of Meats Cooked by Roasting, Broiling, Sautéing, and Frying.

The results of the analysis of the cold-water extracts of meats which were cooked by roasting, broiling, sautéing, and frying are summarized in Tables 113 and 114.

Table 113.—*Chemical composition of cold-water extracts of meats cooked by roasting, broiling, sautéing, and frying (fresh substance).*

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat and method of cooking.	Proteid.	Organic extractives.			Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Nonproteid nitrogen.	Ratio of nonproteid to proteid nitrogen.
					Nitrogenous.	Nonnitrogenous.	Total.							
				P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
1770	1764	146	Beef, round, pot roast	0.31	1.40	1.69	3.09	0	0.84	4.24	0.498	0.050	0.448	1:0.14
1781	1775	155	.....do.................	.42	1.11	1.17	2.28	0	.83	3.53	.421	.067	.354	1: .19
			Average........	.37	1.26	1.43	2.69	0	.83	3.89	.460	.059	.401	1: .15
1771	1764	147	Beef, round, roast....	.75	1.36	1.55	2.91	0	.96	4.62	.557	.119	.438	1: .27
1782	1775	156	.....do.................	1.23	.94	1.27	2.21	0	.95	4.39	.497	.197	.300	1: .66
			Average........	.99	1.15	1.41	2.56	0	.96	4.51	.527	.158	.369	1: .43
1660	1662	120	Veal, leg, roast.......	.41	1.34	1.89	3.23	0	1.18	4.82	.496	.066	.430	1: .15
			Average Nos. 1660, 1771 and 1782..........	.80	1.21	1.57	2.78	0	1.03	4.61	.517	.128	.389	1: .33
1778	1775	152	Beef, round, gas broiled............	.83	1.38	1.62	3.00	0	1.01	4.84	.575	.133	.442	1: .30
1766	1764	142	Beef, round, pan broiled.............	1.37	1.46	1.72	3.18	0	.99	5.54	.686	.219	.467	1: .47
1777	1775	151	.....do.................	.58	1.48	1.72	3.20	0	1.05	4.83	.569	.094	.475	1: .20
			Average Nos. 1766 and 1777.	.98	1.47	1.72	3.19	0	1.02	5.19	.628	.156	.472	1: .33
1674	1676	124	Beef, rump, pan broiled............	.27	1.07	1.33	2.40	0	1.07	3.74	.387	.044	.343	1: .13
1659	1662	119	Veal, leg, pan broiled.............	.42	1.33	1.84	3.17	0	1.29	4.88	.494	.068	.426	1: .16
			Average Nos. 1659, 1674, 1766 and 1777......	.66	1.34	1.65	2.99	0	1.10	4.75	.534	.106	.428	1: .25
1765	1764	141	Beef, round, sautéed.	1.03	1.38	1.69	3.07	0	.94	5.04	.608	.165	.443	1: .37
1776	1775	150	.....do.................	.73	1.37	1.61	2.98	0	.95	4.66	.556	.116	.440	1: .26
			Average........	.88	1.38	1.65	3.03	0	.94	4.85	.582	.141	.441	1: .32
1767	1764	143	Beef, round, fried....	.53	1.62	1.83	3.45	0	1.09	5.07	.605	.086	.519	1: .17
			Average of all beef samples.	.73	1.33	1.56	2.89	0	.97	4.59	.542	.117	.425	1: .28
			Average of all veal samples.	.41	1.34	1.87	3.21	0	1.23	4.85	.495	.067	.428	1: .16
			Average of all beef and veal samples......	.68	1.33	1.61	2.94	0	1.01	4.63	.535	.109	.426	1: .26

Table 114.—*Chemical composition of cold-water extracts of meats cooked by roasting, broiling, sautéing, and frying (water-free substance).*

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat and method of cooking.	Proteid.	Organic extractives.			Fat.	Ash.	Total solid matter.	Total nitrogen.	Proteid nitrogen.	Nonproteid nitrogen.
					Nitrogenous.	Nonnitrogenous.	Total.						
				P. ct.	*P. ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1770	1764	146	Beef, round, pot roast	0.65	2.91	3.52	6.43	0	1.75	8.83	1.036	0.105	0.931
1781	1775	155	.....do	.89	2.36	2.49	4.85	0	1.76	7.50	.895	.142	.753
			Average	.77	2.64	3.01	5.65	0	1.75	8.17	.966	.124	.842
1771	1764	147	Beef, round, roast	2.10	3.84	4.38	8.22	0	2.71	13.03	1.574	.338	1.236
1782	1775	156	.....do	3.91	2.99	4.04	7.03	0	3.02	13.96	1.582	.626	.956
			Average	3.01	3.42	4.21	7.63	0	2.86	13.50	1.578	.482	1.096
1660	1662	120	Veal, leg, roast	1.30	4.23	5.97	10.20	0	3.73	15.23	1.566	.210	1.356
			Average Nos. 1660, 1771, and 1782	2.44	3.69	4.79	8.48	0	3.15	14.07	1.574	.391	1.183
1778	1775	152	Beef, round, gas broiled	2.46	4.09	4.80	8.89	0	2.99	14.34	1.705	.393	1.312
1766	1764	142	Beef, round, pan broiled	3.98	4.25	5.00	9.25	0	2.88	16.11	1.996	.636	1.360
1777	1775	151	.....do	1.69	4.32	5.02	9.34	0	3.07	14.10	1.662	.273	1.389
			Average	2.84	4.29	5.01	9.30	0	2.97	15.11	1.829	.455	1.374
1674	1676	124	Beef, rump, pan broiled	.37	1.48	1.83	3.31	0	1.48	5.16	.534	.060	.474
1659	1662	119	Veal, leg, pan broiled	1.21	3.84	5.31	9.15	0	3.72	14.08	1.425	.196	1.229
			Average Nos. 1659, 1674, 1766, and 1777	1.81	3.47	4.29	7.76	0	2.79	12.36	1.404	.291	1.113
1765	1764	141	Beef, round, sautéed	2.87	3.84	4.70	8.54	0	2.62	14.03	1.690	.459	1.231
1776	1775	150	.....do	2.19	4.11	4.83	8.94	0	2.85	13.98	1.667	.347	1.320
			Average	2.53	3.98	4.77	8.75	0	2.73	14.01	1.679	.403	1.276
1767	1764	143	Beef, round, fried	1.26	3.84	4.33	8.17	0	2.58	12.01	1.433	.203	1.230
			Average of all beef samples	2.04	3.46	4.09	7.55	0	2.52	12.11	1.434	.326	1.108
			Average of all veal samples	1.26	4.04	5.64	9.68	0	3.73	14.67	1.496	.203	1.293
			Average of all beef and veal samples	1.92	3.55	4.33	7.88	0	2.71	12.51	1.444	.307	1.137

The cold-water extract from the 13 samples of beef and veal cooked by dry heat contained on an average 0.68 per cent proteid, 1.33 per cent nitrogenous extractives, 1.61 per cent nonnitrogenous extractives, 2.94 per cent total organic extractives, and 1.01 per cent mineral matter, making a total of 4.63 per cent soluble matter. The total nitrogen averaged 0.535 per cent, of which 0.109 per cent was present as proteid, and 0.426 per cent as nonproteid nitrogen. The ratio of nonproteid to proteid nitrogen was 1:0.26.

As will be seen by comparison of these figures with those for raw meat and for boiled meat given on pages 127 and 129, the meats cooked by dry heat contain less soluble material than raw meats but more soluble constituents than boiled meats. It is, however, more satisfactory to compare the results on a water-free basis. Stated in this form (see Table 114), cold water extracted on an average from the 13 samples of meats cooked by dry heat 1.92 per cent proteid, 3.55 per cent nitrogenous extractives, 4.33 per cent nonnitrogenous extractives, 7.88 per cent total organic extractives, 2.71 per cent ash, and 12.51 per cent total soluble matter.

The corresponding data for the raw and for boiled meats have already been given (see Tables 109 and 111, pp. 127 and 132). From the experimental data thus presented it is evident that meats cooked by dry heat are 2.4 times as soluble as boiled beef, but only a little more than one-half as soluble as raw meats. The chief differences in the solubility of meats cooked by roasting, etc., and raw meats is due to the much smaller content of soluble proteid matter, which is 6.38 per cent less than in the raw meat. Meats cooked by dry heat also contain on an average 2.04 per cent less of total organic extractives and 0.38 per cent less ash.

It is also apparent from the data presented in Tables 111 and 114 that the water-free substance of roast meats contains about 2.3 as much soluble proteids and nonnitrogenous extractives and 2.5 as much nitrogenous extractives and ash as the water-free substance of boiled meats. The more pronounced flavor of meats cooked by dry heat as compared with those cooked in hot water is without doubt due to these additional soluble constituents.

In the light of our present knowledge the cooked meats containing this greater amount of soluble organic and inorganic substances must be considered somewhat more nutritious and palatable.

These conclusions are in accord with the opinion commonly held, namely, that roast meats and meats cooked in other ways by dry heat are more savory and nutritious than boiled meats. If the broth from boiled meat is used as soup, gravy or otherwise, of course the total nutritive value of the meat is retained, and the boiled meat with the soup surpasses the roast. The factors which influence palatability are also to be considered, and here the advantage is with the meat cooked by dry heat. From a practical standpoint the differences in the nutritive value of meats cooked by dry heat and those cooked in hot water are not great enough to be of much importance, though as regards qualities which make up flavor the roast meat surpasses the boiled.

Tables 115 and 116, which follow, summarize the data regarding the composition of the cold-water extracts of raw meat, boiled meat, and meat cooked by dry heat.

Table 115.—*Average composition of the cold-water extracts of uncooked, boiled, and dry-cooked meats (expressed in percentage of the weight of meat taken).*

Kind of meat and method of cooking.	No. in average.	Proteid.	Organic extractives.			Fat.	Ash.	Total solid matter.	Nitrogen.			Ratio of nonproteid to proteid nitrogen.
			Nitrogenous.	Non-nitrogenous.	Total.				Proteid.	Non-proteid.	Total.	
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Beef, uncooked	11	2.29	1.08	1.62	2.70	0	0.83	5.82	0.367	0.346	0.713	1:1.06
Veal, uncooked	2	2.37	1.17	1.66	2.83	0	.95	6.15	.378	.375	.753	1:1.01
Beef, boiled three hours	14	.26	.75	.88	1.63	0	.49	2.38	.042	.241	.283	1: .17
Beef, boiled five hours	17	.47	.47	.65	1.12	0	.39	1.98	.074	.151	.225	1: .49
Beef, boiled three and five hours	31	.38	.60	.75	1.35	0	.44	2.17	.060	.191	.251	1: .31
Beef, pot roast	2	.37	1.26	1.43	2.69	0	.83	3.89	.059	.401	.460	1: .15
Beef, roast	2	.99	1.15	1.41	2.56	0	.96	4.51	.158	.369	.527	1: .43
Veal, roast	1	.41	1.34	1.89	3.23	0	1.18	4.82	.066	.430	.496	1: .15
Beef, gas broiled	1	.83	1.38	1.62	3.00	0	1.01	4.84	.133	.442	.575	1: .30
Beef, pan broiled	3	.71	1.34	1.59	2.93	0	1.04	4.71	.119	.429	.548	1: .26
Veal, pan broiled	1	.42	1.33	1.84	3.17	0	1.29	4.88	.068	.426	.494	1: .16
Beef, sautéed	2	.88	1.38	1.65	3.03	0	.94	4.85	.141	.441	.582	1: .32
Beef, fried	1	.53	1.62	1.83	3.45	0	1.09	5.07	.086	.519	.605	1: .17

Table 116.—*Average composition of the cold-water extracts of uncooked, boiled, and dry-cooked meats (water-free substance).*

Kind of meat and method of cooking.	No. in average.	Proteid.	Organic extractives.			Fat.	Ash.	Total solid matter.	Nitrogen.		
			Nitrogenous.	Non-nitrogenous.	Total.				Proteid.	Non-proteid.	Total.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Beef, uncooked	11	8.14	3.83	5.78	9.61	0	2.94	20.69	1.303	1.229	2.532
Veal, uncooked	2	9.77	4.83	6.84	11.67	0	3.94	25.38	1.564	1.544	3.108
Beef, boiled three hours	14	.61	1.74	2.05	3.79	0	1.13	5.52	.097	.560	.657
Beef, boiled five hours	17	1.16	1.18	1.66	2.84	0	1.00	5.00	.184	.377	.561
Beef, boiled three and five hours	31	.88	1.43	1.84	3.27	0	1.06	5.23	.145	.459	.604
Beef, pot roast	2	.77	2.64	3.01	5.65	0	1.75	8.17	.124	.842	.966
Beef, roast	2	3.01	3.42	4.21	7.63	0	2.86	13.50	.482	1.096	1.578
Veal, roast	1	1.30	4.23	5.97	10.20	0	3.73	15.23	.210	1.356	1.566
Beef, gas broiled	1	2.46	4.09	4.80	8.89	0	2.99	14.34	.393	1.312	1.705
Beef, pan broiled	3	2.02	3.35	3.95	7.30	0	2.47	11.79	.323	1.074	1.397
Veal, pan broiled	1	1.21	3.84	5.31	9.15	0	3.72	14.08	.196	1.229	1.425
Beef, sautéed	2	2.53	3.98	4.77	8.75	0	2.73	14.01	.403	1.276	1.679
Beef, fried	1	1.26	3.84	4.33	8.17	0	2.58	12.01	.203	1.230	1.433

THE AMOUNT AND NATURE OF THE NITROGENOUS CONSTITUENTS OF UNCOOKED AND COOKED MEATS.

In a study of the chemistry of the digestion of meats, and the nutritive value of flesh foods, it is highly desirable that the present very limited knowledge of the nitrogenous principles as they exist in raw and cooked meats be extended.

Such a study is difficult for several reasons. In the first place, a considerable number of the nitrogenous constituents of flesh are as yet unidentified as individual and characteristic compounds, and the data regarding the physical and chemical properties of those which are known are very incomplete and contradictory. In the second place, the methods for the qualitative and quantitative separation and estimation of the various nitrogenous bodies known to exist in animal substances are very far from satisfactory.

In recent years much attention has been directed to the study of the chemical structure of proteids of animal and vegetable origin, especially as shown by the number and nature of the cleavage products obtained by the action of different reagents. In this connection the animal proteids are of especial interest. They have been found to vary very greatly in complexity from scombrin, obtained from the reproductive organs of mackerel, which, according to Kossel and Dakin,[a] yields only three or four cleavage products, to such bodies as casein, globin, etc. According to E. Fischer's[b] investigations, casein yields 16 cleavage products and in globin, a body isolated from the oxyhemoglobin of horse blood, Abderhalden[c] has identified 14 cleavage products. Some of the proteids studied are of importance from the standpoint of nutrition, while others are not of so great interest in this connection; but as a whole such studies are of undoubted value because of the data they provide regarding the chemical nature of nitrogenous foods, and it is fortunate that so many chemists are turning their attention to these problems.

In their study of the relative merits of white and red meat in invalid dietetics, Offer and Rosenquist[d] determined the total nitrogen, nitrogen of extractives, and nitrogen of meat bases in a large number of samples of fish, poultry, veal, pork, beef, mutton, venison, and salted and smoked meats. In some cases analyses were made with cooked samples, but in most cases with the raw meat. The smallest proportion of total nitrogen, 2.54 per cent, was reported in a sample of pork; the highest, 4.09 per cent, in dried beef. The majority of the samples contained from 0.4 to 0.5 per cent nitrogen of extractives. Less than 0.4 per cent was noted in samples of boiled beef (soup meat), fillet of beef, pork, and chicken, and over 0.5 per cent in pike, perch, scraped beef, and raw and cooked ham. In the case of nitrogen of meat bases the largest proportions, 0.071, 0.056, and 0.05 per cent, were reported in scraped beef, pork, and boiled beef (soup meat), respectively, and the smallest proportions, 0.009 and 0.007 per cent, respectively, in venison and pike.

E. Zunz[e] studied some of the constituents of veal. When 5 kilograms of lean veal, taken three-quarters of an hour after the calf was slaughtered, was boiled, 0.679 gram histidin, 0.138 gram arginin, 0.559 gram lysin, 0.227 gram leucin, 0.662 gram glutaminic acid, and 0.371 gram aspartic acid were recovered.

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[a] Ztschr. Physiol. Chem., 44 (1905), p. 342. See also Kossel, Ibid., p. 347.

[b] Ztschr. Physiol. Chem., 33 (1901), p. 151.

[c] Ztschr. Physiol. Chem., 37 (1903), p. 499.

[d] Berlin. Klin. Wchnschr., 36 (1899), pp. 937, 968, 1086.

[e] Ann. Soc. Roy. Sci. Méd. et Nat. Bruxelles, 13 (1904); abs. in Zentbl. Physiol., 18 (1904), p. 852.

In connection with the investigations here reported it was believed that a study of the nature and amount of the nitrogenous constituents of raw and cooked meat, which are ordinarily regarded as of particular importance in discussions of nutritive value, would prove useful, and so an investigation of this sort was undertaken.

The methods used to obtain the figures quoted have already been described (pp. 13-15). The results of the experimental work are given below.

FORMS OF NITROGEN IN UNCOOKED MEATS.

The data regarding the form in which nitrogen occurs in the cold-water extract of raw meat are summarized in Tables 117-119. Table 117, showing the data calculated on the basis of the total weight of the meat, follows.

TABLE 117.—*Nitrogen records of the cold-water extracts of raw meats (results expressed in percentage of meat taken).*

Laboratory No.	Cooking experiment No.	Kind of meat.	Total nitrogen in meat.	Total nitrogen in water extract.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumoses).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$.	Proteid nitrogen in water extract.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1672	122	Beef, flank, raw	2.479	0.1101	0.1741	0.0122	0.1866	0.0072	0.1938
1668	121	Beef, neck, raw	3.098	.6266	.3116	.0214	.3630	.0052	.3682
1637	107	Beef, round, raw	3.390	.7896	[a].0416	[a].1001	.4420	....	.4420
1640	108-109	.....do	3.580	.8832	[a].0602	[a].3831	.4433	....	.4433
1647	110-113	.....do	3.350	.7410	.2221	.0609	.2830	.0088	.2918
1722	131-132	.....do	3.392	.7913	.3996	.0327	.4323	....	.4323
1741	133-136	.....do	3.424	.8457	.4105	.0375	.4480	....	.4480
1753	137-140	.....do	3.433	.7391	.3586	.0244	.3830	....	.3830
1764	141-147	.....do	3.251	.8105	.4048	.0276	.4324	....	.4324
1775	150-156	.....do	3.349	.7142	.3366	.0154	.3520	....	.3520
		Average Nos. 1637, 1640, 1647, 1722, 1741, 1753, 1764, and 1775	3.396	.7897	.3554	.0331	.4021	.0088	[a].4031
1676	123-124	Beef, rump, raw	2.400	.4560	.2233	.0200	.2432	.0027	.2459
		Average of all beef samples	3.195	.7128	.3191	.0280	[a].3645	[b].0060	[a].3665
1656	114-116	Veal, leg, raw	3.470	.8549	.3963	.0137	.4400	.0120	.4520
1662	117-120	.....do	3.230	.6503	.2644	.0238	.2882	.0150	.3032
		Average	3.350	.7526	.3303	.0388	.3641	.0135	.3776
		Average of all beef and veal samples	3.219	.7189	.3211	.0290	.3644	[c].0085	.3682

[a] Not included in average.

[b] Average of 3 analyses.

[c] Average of 5 analyses.

TABLE 117.—*Nitrogen records of the cold-water extracts of raw meats (results expressed in percentage of meat taken)*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat.	Nonproteid nitrogen in water extract	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen as ammonia.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1672	122	Beef, flank, raw	0.1463	0.1903	0.2114	0.2286	0.2516	....	0.0105
1668	121	Beef, neck, raw	.2584	.2129	.2948	.2978	.3205	....	.0410
1637	107	Beef, round, raw	.3476	....	....	.3785	.3970	....	....
1640	108–109	.....do	.4399	....	....	.4817	.4622	....	....
1647	110–113	.....do	.4522	....	....	.3706	.3600	....	.0005
1722	131–132	.....do	.3590	....	.4129	.3940	.3970	0.3318	.1810
1741	133–136	.....do	.3977	....	.4274	.4505	.4126	.2368	.0162
1753	137–140	.....do	.3561	....	.4181	.3718	.3735	.3988	.0161
1764	141–147	.....do	.3781	....	.4437	.4210	.4120	.4613	.0148
1775	150–156	.....do	.3622	....	.3750	.3492	.3803	.3876	.0139
		Average Nos. 1637, 1640, 1647, 1722, 1741, 1753, 1764, and 1775	.3866	....	[a].4154	.4022	.4031	[a].3632	[b].0404
1676	123–124	Beef, rump, raw	.2100	.1834	.2206	.2231	.2258	....	.0122
		Average of all beef samples	.3462	[c].1955	[d].3505	.3606	.3657	[a].3633	.0340
1656	114–116	Veal, leg, raw	.4029	.3704	.3888	.4418	.4192	....	.0134
1662	117–120	.....do	.3471	.2257	.2350	.2897	.2534	....	.0199
		Average	.3750	.2981	.3119	.3658	.3363	....	.0167
		Average of all beef and veal samples	.3506	[c].2365	[e].3428	.3614	.3612	[a].3633	.0309

[a] Average of 5 analyses.
[b] Average of 6 analyses.
[c] Average of 3 analyses.
[d] Average of 8 analyses.
[e] Average of 10 analyses.

It will be seen that the total nitrogen in the uncooked meats (beef and veal) varies from 2.400 per cent in very fat beef rump (sample No. 1676) to 3.580 per cent in lean beef round (sample No. 1640), the average for 13 samples of uncooked meat being 3.219 per cent.

The total nitrogen soluble in cold water formed 0.4401 to 0.8832 per cent of the weight of the meat. The lowest figures were obtained with sample No. 1672, very fat beef flank, and the highest as before, with sample No. 1640, lean beef round. It will be observed further that the water-soluble nitrogen bears a direct relation to the total nitrogen in the meat. In other words, the more nitrogen there is in the meat the greater is the amount which will be dissolved by cold water. The average figures for nitrogen of compounds soluble in cold water are 0.7128 per cent for 11 samples of beef, and 0.7526 per cent for 2 samples of veal, the average for the beef and veal together being 0.7189 per cent.

The nitrogen in the form of proteids coagulable by heat in neutral solution varied from 0.1744 per cent in the beef flank (sample No. 1672), to 0.4105 per cent in a sample of beef round (No. 1741), the average for the raw meats being 0.3211 per cent of the entire weight of the fresh meats. The albumose nitrogen, as determined by precipitation with zinc sulphate, was, as a rule, less than one-tenth of the nitrogen coagulated by heat. The average found in the 11 samples of fresh beef was 0.0280 per cent, and in the 2 samples of veal 0.0388 per cent.

In a few of the raw meats the nitrogen in the form of peptones was determined by treating with bromin the filtrate from the zinc sulphate precipitate. Only a very small amount of precipitate was obtained, the average quantity in the six tests being 0.0085 per cent. It has recently been fully demonstrated[a] that the use of bromin as a precipitant for proteids can not be relied upon.

For the time being we have assumed that the sum of the nitrogen coagulated by heat and that precipitated as albumoses by zinc sulphate represents the total soluble proteid nitrogen, except that in the cases where bromin has been used as a reagent the nitrogen thus precipitated has also been included in the proteid nitrogen. Investigations made in this laboratory lead to the belief that neither of these methods gives entirely trustworthy results, but that for the time being the first is in all probability the better method, notwithstanding the fact that the filtrate from the zinc sulphate precipitate still contains traces of nitrogen in the form of proteid. While the results thus obtained for the soluble proteid nitrogen can not be considered final and conclusive, they undoubtedly approximate the truth, and there is no doubt that by the careful use of these methods comparable results may be obtained.

The nitrogen of soluble proteid in the uncooked meats analyzed varied from 0.1938 per cent in beef flank (sample No. 1672) to 0.4520 per cent in veal leg (sample No. 1656), the average for the 13 samples of raw beef and veal being 0.3682 per cent. The nitrogen in the form of nonproteid substances is quite similar in amount to the nitrogen of the soluble proteids, and apparently varies directly as the latter. The nonproteid nitrogen varied from 0.1463 to 0.4522 per cent of the weight of the raw meats, the average for the 13 samples of beef and veal being 0.3506 per cent.

The data obtained indicate that there is a small amount of nitrogen invariably present in the form of ammonia or ammonium salts in cold-water extracts of raw flesh. This has been found to be true even where barium carbonate was used to remove the ammonia by distillation.

As pointed out by C. Mai,[b] the ratio of ammonia nitrogen to total nitrogen increases after meat has been hung for three or four days.

It is expected that a discussion of the relative value of bromin, phosphotungstic acid, tannin, and Stutzer's reagent for the estimation and separation of proteid and nonproteid substances will be considered in some detail in another publication from this laboratory, the distinctly chemical work connected with the cooperative investigations with meat having been carried on for the University of Illinois. It will be sufficient at this time to say that these reagents precipitated from cold-water extracts of raw meats the following average quantities of nitrogen, expressed in percentage of the weight of fresh flesh taken: Bromin, 0.2365 per cent; phosphotungstic acid in a hot solution, 0.3428 per cent; phosphotungstic acid in a cold solution, 0.3612 per cent; tannin and salt, 0.3614 per cent, and Stutzer's reagent, 0.3633 per cent.

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[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 81, pp. 104, 117, and 228.

[b] Ztschr. Untersuch. Nahr. u. Genussmtl., 4 (1901), No. 1, p. 18.

In order to get another point of view for these nitrogen values for the uncooked meats, the results have been calculated to percentages of the total nitrogen of the flesh taken for examination.

TABLE 118.—*Nitrogen records of the cold-water extracts of raw meats (results expressed in percentage of total nitrogen of meat taken).*

Laboratory No.	Cooking experiment No.	Kind of meat.	Total nitrogen in meat.	Total nitrogen in water extract.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$ precipitate.	Proteid nitrogen in water extract.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1672	122	Beef, flank, raw	100	17.76	7.03	0.49	7.52	0.29	7.81
1668	121	Beef, neck, raw	100	20.22	11.03	.69	11.72	.17	11.89
1637	107	Beef, round, raw	100	23.29	[a]1.23	[a]11.81	13.04	....	13.04
1640	108-109	.....do	100	24.67	[a]1.68	[a]10.70	12.38	....	12.38
1647	110-113	.....do	100	22.21	6.63	1.82	8.45	.26	8.71
1722	131-132	.....do	100	23.33	11.78	.96	12.74	....	12.74
1741	133-136	.....do	100	24.70	11.99	1.10	13.09	....	13.09
1753	137-140	.....do	100	21.53	10.45	.71	11.16	....	11.16
1764	141-147	.....do	100	24.93	12.45	.85	13.30	....	13.30
1775	150-156	.....do	100	21.33	10.05	.46	10.51	....	10.51
		Average Nos. 1637, 1640, 1647, 1722, 1741, 1753, 1764, and 1775	100	23.25	10.56	.98	11.83	....	11.87
1676	123-124	Beef, rump, raw	100	19.00	9.30	.83	10.14	.11	10.25
		Average of all beef samples	100	22.09	10.08	.88	11.28	[b].21	11.35
1656	114-116	Veal, leg, raw	100	24.64	11.42	1.26	12.68	.35	13.03
1662	117-120	.....do	100	20.13	8.18	.74	8.92	.46	9.38
		Average	100	22.39	9.80	1.00	10.80	.41	11.21
		Average of all beef and veal samples	100	22.14	10.03	.90	11.21.	[c].28	11.33

[a] Not included in average. [b] Average of 3 analyses. [c] Average of 5 analyses.

TABLE 118.—*Nitrogen records of the cold-water extracts of raw meats (results expressed in percentage of total nitrogen of meat taken)*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat.	Nonproteid nitrogen in water extract.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen as free ammonia.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1672	122	Beef, flank, raw	9.95	7.67	8.53	9.23	10.16	....	0.12
1668	121	Beef, neck, raw	8.33	6.87	9.77	9.61	10.31	....	1.32
1637	107	Beef, round, raw	10.25	....	....	11.16	11.71	....	....
1640	108-109	.....do	12.29	....	....	13.46	12.91	....	....
1647	110-113	.....do	13.50	....	....	11.06	10.75	....	.01
1722	131-132	.....do	10.59	....	12.17	11.62	11.71	9.78	....
1741	133-136	.....do	11.61	....	12.48	13.16	12.93	6.92	.47
1753	137-140	.....do	10.37	....	12.18	10.83	10.88	11.62	.47
1764	141-147	.....do	11.63	....	13.65	12.95	12.67	14.19	.45
1775	150-156	.....do	10.82	....	11.20	10.43	11.36	11.58	.42
		Average Nos. 1637, 1640, 1647, 1722, 1741, 1753, 1764, and 1775	11.38	....	[a] 12.34	11.83	[a] 11.87	10.82	[b] .36
1676	123-124	Beef, rump, raw	8.75	7.64	9.19	9.30	9.42	....	.51
		Average of all beef samples	10.74	[c] 7.39	[d] 11.15	11.16	11.35	[a] 10.82	.51
1656	114-116	Veal, leg, raw	11.61	10.67	11.20	12.74	12.10	....	.39
1662	117-120	.....do	10.75	6.99	7.28	8.97	7.84	....	.61
		Average	11.18	8.83	9.24	10.86	9.97	....	.50
		Average of all beef and veal samples	10.81	[a] 7.97	[e] 10.77	11.11	11.14	[d] 10.82	.51

[a] Average of 5 analyses.
[b] Average of 6 analyses.
[c] Average of 3 analyses.
[d] Average of 8 analyses.
[e] Average of 10 analyses.

It will be observed that the soluble nitrogen found in raw meats formed 17.76 to 24.93 per cent of the total nitrogen contained in the flesh. The average amount of soluble nitrogen in terms of the total nitrogen in the 13 samples of uncooked beef and veal was 22.14 per cent. The nitrogen in the form of proteids coagulated by heat in neutral solution ranged from 6.63 per cent in a sample of beef round (No. 1647), to 12.45 per cent in another sample of this cut (No. 1764), the average for the uncooked meat being 10.03 per cent.

The average albumose nitrogen of the raw meats was 0.90 per cent. The average amount of nitrogen precipitated by bromin in the filtrate from the zinc sulphate precipitate in the 6 samples in which it was determined amounted to only 0.28 per cent of the total nitrogen. The soluble proteid nitrogen amounted to 11.33 per cent, the nonproteid nitrogen to 10.81 per cent, and the nitrogen in the form of ammonia or ammonium salts to 0.51 per cent of the total nitrogen present.

The different reagents used precipitated from cold-water extracts of raw meats the following average quantities of nitrogen: Bromin, 7.97

per cent; phosphotungstic acid in a hot solution, 10.77 per cent; phosphotungstic acid in a cold solution, 11.14 per cent; tannin and salt, 11.11 per cent, and Stutzer's reagent 10.82 per cent.

The nitrogen values for cold-water extracts of raw meat have also been calculated to the basis of total soluble nitrogen present, the results being given in Table 119.

TABLE 119.—*Nitrogen records of the cold-water extracts of raw meats (results expressed in percentage of total nitrogen of cold-water extract).*

Laboratory No.	Cooking experiment No.	Kind of meat.	Total nitrogen in meat.	Total nitrogen in water extract.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$ precipitate.	Proteid nitrogen in water extract.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1672	122	Beef, flank, raw	2.479	100	39.63	2.77	42.40	1.64	44.04
1668	121	Beef, neck, raw	3.098	100	54.52	3.41	57.93	.83	58.76
1637	107	Beef, round, raw	3.390	100	[a]5.27	[a]50.71	55.98	....	55.98
1640	108-109	.....do	3.580	100	[a]6.82	[a]43.38	50.20	....	50.20
1647	110-113	.....do	3.350	100	29.85	8.19	38.04	1.18	39.23
1722	131-132	.....do	3.392	100	50.50	4.13	54.63	....	54.63
1741	133-136	.....do	3.424	100	48.54	4.43	52.97	....	52.97
1753	137-140	.....do	3.433	100	48.52	3.30	51.82	....	51.82
1764	141-147	.....do	3.251	100	49.94	3.41	53.35	....	53.35
1775	150-156	.....do	3.349	100	47.13	2.16	49.29	....	49.29
		Average Nos. 1637, 1640, 1617, 1722, 1741, 1753, 1764, and 1775	3.396	100	45.75	4.27	50.79	....	[a]50.93
1676	123-124	Beef, rump, raw	2.400	100	48.97	4.39	53.36	.59	53.95
		Average of all beef samples	3.195	100	46.40	4.02	50.90	[b]1.06	[a]51.29
1656	114-116	Veal, leg, raw	3.470	100	46.36	5.11	51.47	1.40	52.87
1662	117-120	.....do	3.230	100	40.66	3.66	44.32	2.29	46.61
		Average	3.350	100	43.51	4.38	47.89	1.85	49.74
		Average of all beef and veal samples	3.219	100	45.87	4.09	50.44	[c]1.32	51.05

[a] Not included in average. [b] Average of 3 analyses. [c] Average of 5 analyses.

TABLE 119.—*Nitrogen records of the cold-water extracts of raw meats (results expressed in percentage of total nitrogen of cold-water extract*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat.	Nonproteid nitrogen in water extract.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen as free ammonia.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1672	122	Beef, flank, raw	55.96	43.21	48.04	51.94	57.17	....	2.38
1668	121	Beef, neck, raw	41.21	33.98	48.15	47.54	51.15	....	6.54
1637	107	Beef, round, raw	41.02	....	....	47.91	50.28	....	....
1640	108-109	.....do	49.80	....	....	54.54	52.33	....	....
1647	110-113	.....do	60.77	....	....	49.81	48.39	....	.07
1722	131-132	.....do	45.37	....	52.18	49.79	50.17	41.93	....
1741	133-136	.....do	47.03	....	50.51	53.27	52.34	28.00	1.92
1753	137-140	.....do	48.18	....	56.57	50.30	50.53	53.96	2.18
1764	141-147	.....do	46.65	....	54.74	51.91	50.83	56.92	1.83
1775	150-156	.....do	50.71	....	52.51	48.89	53.25	54.27	1.95
		Average Nos. 1637, 1640, 1647, 1722, 1741, 1753, 1764, and 1775	49.07	....	[a]53.31	50.81	[a]51.02	47.02	[b]1.59
1676	123-124	Beef, rump, raw	46.05	40.22	48.38	48.93	49.52	....	2.67
		Average of all beef samples	48.71	[c]39.15	[d]51.39	50.44	51.45	[a]47.02	2.44
1656	114-116	Veal, leg, raw	47.13	43.33	45.48	51.68	49.03	....	1.57
1662	117-120	.....do	53.39	31.71	36.14	44.55	38.97	....	3.06
		Average	50.26	39.02	40.81	48.12	44.00	....	2.32
		Average of all beef and veal samples	48.95	[a]39.10	[e]49.27	50.08	50.30	[a]47.02	2.42

[a] Average of 5 analyses.

[b] Average of 6 analyses.

[c] Average of 3 analyses.

[d] Average of 8 analyses.

[e] Average of 10 analyses.

From the foregoing table it will be seen that 29.85 to 54.52 per cent of the soluble nitrogen was present in the form of compounds coagulable by heat, the average quantity for the 13 samples of raw flesh being 45.87 per cent of the total nitrogen of soluble compounds precipitated by coagulation. By saturating the filtrate from the coagulated proteid with zinc sulphate from 2.16 to 8.19 per cent of the soluble nitrogen was precipitated as albumoses, the average amount being 4.09 per cent. The average amount of nitrogen precipitated supposedly as peptones by bromin in the filtrate from the zinc sulphate precipitate in six samples of raw meats was equal to 1.32 per cent of the total soluble nitrogen.

The nitrogen of soluble proteids formed 39.23 to 58.76 per cent of the total soluble nitrogen, averaging for the 13 samples 51.05 per cent. The nonproteid nitrogen ranged from 41.24 to 60.77 per cent of the total soluble nitrogen, the average being 48.95 per cent, and the nitrogen existing as ammonia or ammonium salts was on an average 2.42 per cent.

The other reagents used precipitated the following average quantities of nitrogen expressed in terms of total soluble nitrogen: Bromin, 39.10 per cent, phosphotungstic acid in a hot solution 49.27 per cent, phosphotungstic acid in a cold solution 50.30 per cent, tannin and salt 50.08 per cent, and Stutzer's reagent 47.02 per cent.

FORMS OF NITROGEN IN MEATS COOKED BY BOILING.

In the following pages the data regarding the different forms of nitrogen existing in meats cooked by boiling are summarized, Table 120 showing the data calculated on the basis of the amount of meat used:

TABLE 120.—*Nitrogen records of the cold-water extracts of meats cooked by boiling (results expressed in percentage of meat taken).*

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Total nitrogen in meat.	Total nitrogen in water extract.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumoses).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$.
				At beginning.	During cooking.							
				°C.	*°C.*	*Hrs.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1642	1640	109	Beef, round	Cold.	85	3	5.770	0.1598	0.0025	0.0189	0.0214	......
1751	1753	137	....do	Cold.	85	3	5.884	.2823	0	.0321	.0321	......
			Average	Cold.	85	3	5.827	.2211	.0013	.0255	.0268	......
1756	1753	139	Beef, round (browned)	Cold.	85	3	5.495	.2677	0	.0279	.0279	......
			Average Nos. 1642, 1754, and 1756	Cold.	85	3	5.716	.2366	.0008	.0263	.0271	......
1746	1741	136	Beef, round (browned)	85	85	3	5.696	.2595	.0018	.0223	.0241	......
1769	1764	145	Beef, round	85	85	3	5.810	.3388	.0075	.0271	.0346	......
1780	1775	154	....do	85	85	3	6.040	.2764	0	.0205	.0205	......
			Average Nos. 1769 and 1780	85	85	3	5.925	.3076	.0038	.0238	.0276	......
			Average Nos. 1746, 1769, and 1780	85	85	3	5.849	.2916	.0031	.0233	.0264	......
1641	1640	108	Beef, round	100	85	3	5.910	.1684	.0363	.0252	.0615	......
1714	1741	134	....do	100	85	3	5.862	.3066	.0064	.0458	.0522	......
1768	1764	144	....do	100	85	3	5.309	.3520	.0109	.0229	.0338	......
1779	1775	153	....do	100	85	3	6.013	.3319	0	.0320	.0320	......
			Average	100	85	3	5.774	.2897	.0134	.0315	.0449	......
1755	1753	138	Beef, round	Cold.	100	3	5.857	.3090	0	.0703	.0703	......
1757	1753	140	Beef, round (browned)	Cold.	100	3	5.855	.3322	0	.0784	.0784	......
			Average	Cold.	100	3	5.856	.3206	0	.0744	.0744	......
1743	1741	133	Beef, round	100	100	3	5.834	.2996	.0031	.0496	.0527	......
1745	1741	135	Beef, round (browned)	100	100	3	5.556	.2701	.0011	.0378	.0389	......
			Average	100	100	3	5.695	.2849	.0021	.0437	.0458	......
			Average of all cooked 3 hours	......	......	3	5.778	.2824	.0050	.0365	.0415	......
1646	1647	113	Beef, round	Cold.	65	5	5.240	.1380	.0062	.0194	.0256	0.0180
1645	1647	112	....do	Cold.	85	5	5.420	.1610	.0074	.0333	.0407	.0163
1654	1656	116	Veal, leg	Cold.	85	5	5.070	.1892	.0117	.0771	.0888	.0064
1658	1662	118	....do	Cold.	85	5	4.800	.1904	.0021	.0284	.0308	.0195
			Average Nos. 1651 and 1658	Cold.	85	5	4.935	.1898	.0070	.0528	.0598	.0130
			Average Nos. 1645, 1651, and 1658	Cold.	85	5	5.097	.1802	.0071	.0463	.0534	.0141

Table 120.—*Nitrogen records of the cold-water extracts of meats cooked by boiling (results expressed in percentage of meat taken)*— Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Total nitrogen in meat.	Total nitrogen in water extract.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumoses).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$.
				At beginning.	During cooking.							
				°*C.*	°*C.*	*Hrs.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1644	1647	111	Beef, round	100	85	5	5.590	0.1740	0.0066	0.0308	0.0374	0.0089
1720	1722	131	do	100	85	5	5.309	.2343	.0075	.0180	.0255	......
			Average	100	85	5	5.450	.2042	.0071	.0244	.0315	......
1665	1668	121	Beef, neck	100	85	5	5.039	.1323	.0021	.0204	.0225	.0074
1673	1676	123	Beef, rump	100	85	5	3.245	.2117	.0098	.0420	.0518	.0091
1703	1705	125	do	100	85	5	4.433	.1536	.0131	.0476	.0607	......
			Average Nos. 1673 and 1703	100	85	5	3.839	.1827	.0115	.0148	.0563	......
1669	1672	122	Beef, flank	100	85	5	3.210	.0769	.0132	.0466	.0598	.0032
1653	1656	115	Veal, leg	100	85	5	5.360	.3012	.0169	.0495	.0664	.0128
1664	1662	117	do	100	85	5	4.900	.2270	.0071	.0353	.0121	.0091
			Average Nos. 1653 and 1661	100	85	5	5.130	.2641	.0120	.0424	.0544	.0110
			Average Nos. 1641 1653, 1664, 1665, 1669, 1673, 1703, and 1720	100	85	5	4.636	.1889	.0096	.0363	.0459	.0084
1639	1637	107	Beef, round	100	100	5	5.640	.3087	.0387	.1160	.1547	......
1643	1647	110	do	100	100	5	5.370	.2880	.0230	.1106	.1336	.0133
1721	1722	132	do	100	100	5	5.324	.2974	.0104	.0789	.0893	......
			Average	100	100	5	5.445	.2980	.0240	.1018	.1258	......
1704	1705	126	Beef, rump	100	100	5	4.583	.3145	.0124	.1316	.1440	......
1652	1656	114	Veal, leg	100	100	5	5.310	.4284	.0138	.0388	.0526	.0177
			Average Nos. 1639, 1643, 1652, 1704, and 1721	100	100	5	5.246	.3274	.0196	.0952	.1148	[a] .0155
			Average of all cooked 5 hours	......	......	5	4.933	.2251	.0119	.0544	.0663	[b] .0118
			Average of all cooked 3 or 5 hours	......	......	......	5.318	.2510	.0088	.0463	.0551	[b] 1.018

[c] Average of 2 analyses.

[b] Average of 12 analyses.

TABLE 120.—*Nitrogen records of the cold-water extracts of meats cooked by boiling (results expressed in percentage of meat taken)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Proteid nitrogen in water extract.	Nonproteid nitrogen in water extract.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen precipitated by alcohol.	Nitrogen as free ammonia.
				P. ct.	*P. ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*	*P. ct.*
1642	1640	109	Beef, round	0.0214	0.1384	......	......	0.0039	0.0102	......	......	......
1754	1753	137	....do	.0321	.2502	......	0.1564	.0420	.0458	0.0882	......	0.0174
			Average	.0268	.1943	......	......	.0230	.0280	......	......	......
1756	1753	139	Beef, round (browned)	.0279	.2398	......	.0116	.0340	.0593	.0832	......	.0159
			Average Nos. 1642, 1754, and 1756	.0271	.2095	......	[a].0840	.0266	.0384	[a].0857	......	[a].0167
1746	1741	136	Beef, round (browned)	.0241	.2354	......	.0083	.0308	.0494	.0291	......	.0130
1769	1764	145	Beef, round	.0346	.3042	......	.0272	.0325	.0345	.0937	......	.0221
1780	1775	154	....do	.0205	.2559	......	.0199	.0156	.0225	.0692	......	.0210
			Average Nos. 1769 and 1780	.0276	.2800	......	.0236	.0241	.0285	.0815	......	.0216
			Average Nos. 1746 1769, and 1780	.0264	.2652	......	.0185	.0263	.0355	.0640	......	.0187
1641	1640	108	Beef, round	.0615	.1069	......	......	.0223	.0325	......	......	......
1744	1741	134	....do	.0522	.2544	......	.0478	.0560	.0568	.0576	......	.0174
1768	1764	144	....do	.0338	.3182	......	.0346	.0172	.0438	.0876	......	.0246
1779	1775	153	....do	.0320	.2999	......	.0334	.0297	.1313	.0913	......	.0164
			Average	.0449	.2448	......	[b].0386	.0313	.0661	.0788	......	.0195
1755	1753	138	Beef, round	.0703	.2387	......	.0700	.0801	.0898	.1193	......	.0230
1757	1753	140	Beef, round (browned)	.0784	.2538	......	.0848	.0888	.0917	.1349	......	.0234
			Average	.0744	.2462	......	.0774	.0845	.0908	.1271	......	.0232
1743	1741	133	Beef, round	.0527	.2469	......	.0199	.0565	.0679	.0492	......	.0192
1745	1741	135	Beef, round (browned)	.0389	.2312	......	.0088	.0368	.0568	.0485	......	.0207
			Average	.0458	.2390	......	.0144	.0467	.0624	.0489	......	.0200
			Average of all cooked 3 hours	.0415	.2410	......	......	.0390	.0566	[c].0793	......	[c].0195
1646	1647	113	Beef, round	.0436	.0944	......	......	.0313	.0202	......	......	.0002
1645	1647	112	....do	.0570	.1040	......	......	.0325	.0356	......	......	.0001
1654	1656	116	Veal, leg	.0952	.0940	0.0131	.0062	......	.0003	......	......	......
1658	1662	118	....do	.0503	.1401	.0275	.0210	.0482	.0595	......	......	.0049
			Average Nos. 1654 and 1658	.0728	.1171	.0203	.0136	......	.0299	......	......	......
			Average Nos. 1645, 1654, and 1658	.0675	.1127	......	......	.0404	.0318	......	......	.0025
1644	1647	111	Beef, round	.0463	.1277	......	......	.0183	.0240	......	......	.0003
1720	1722	131	....do	.0255	.2088	......	.0299	.1048	.1209	.1382	0.0401	.0078
			Average	.0359	.1683	......	......	.0616	.0725	......	......	.0041
1665	1668	121	Beef, neck	.0299	.1024	.0062	.0108	.0322	.0305	......	......	.0119
1673	1676	123	Beef, rump	.0609	.1508	.0103	.0280	.0708	.1018	......	......	.0180
1703	1705	125	....do	.0607	.0929	......	.0240	.0417	.0491	.0611	.0468	.0148
			Average Nos. 1673 and 1703	.0608	.1219	......	.0260	.0563	.0755	......	......	.0164

[a] Average of 2 analyses. [b] Average of 3 analyses. [c] Average of 12 analyses.

TABLE 120.—*Nitrogen records of the cold-water extracts of meats cooked by boiling (results expressed in percentage of meat taken)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Proteid nitrogen in water extract.	Nonproteid nitrogen in water extract.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen precipitated by alcohol.	Nitrogen as free ammonia.
				P. ct.	*P. ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*	*P. ct.*
1669	1672	122	Beef, flank	0.0630	0.0139	0.0062	0.0258	0.0142	0.0487	......	......	......
1653	1656	115	Veal, leg	.0792	.2220	.0263	.0083	.0456	.0613	......	......	0.0040
1664	1662	117	do	.0515	.1755	.0295	.0258	.0452	.0332	......	......	.0214
			Average Nos. 1653 and 1661	.0654	.1988	.0279	.0171	.0454	.0473	......	......	.0127
			Average Nos. 1641, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	.0521	.1368	[a].0157	[b].0218	.0466	.0587	......	......	.0098
1639	1637	107	Beef, round	.1547	.1540	......	......	.1050	.1278	......	......	......
1643	1647	110	do	.1469	.1111	......	......	.1061	.1091	......	......	.0006
1721	1722	132	do	.0893	.2081	......	.1005	.0580	.1063	0.0972	0.0119	.0180
			Average	.1303	.1677	......	......	.0897	.1144	......	......	.0093
1704	1705	126	Beef, rump	.1440	.1705	......	.1151	.1379	.1476	.1211	.1426	.0172
1652	1656	114	Veal, leg	.0703	.3581	.0737	.0630	.0775	.1001	......	......	......
			Average Nos. 1639, 1643, 1652, 1704, and 1721	.1210	.2064	......	.0929	.0969	.1182	.1092	.0773	.0119
			Average of all cooked 5 hours	.0746	.1503	.0241	.0382	.0606	.0692	.1054	.0604	.0085
			Average of all cooked 3 or 5 hours	.0597	.1913	[c].0241	[d].0409	.0505	.0635	[e].0858	.0604	.0136

[a] Average of 5 anaylses.
[b] Average of 7 analyses.
[c] Average of 8 analyses.
[d] Average of 23 analyses.
[e] Average of 16 analyses.

It will be seen that the total nitrogen in the boiled beef and veal ranged from 3.210 per cent in a sample of beef flank (No. 1669) to 6.040 per cent in a sample of beef round (No. 1780), the average for 31 samples of meats cooked in hot water being 5.318 per cent.

The total nitrogen of compounds soluble in cold water formed 0.0769 to 0.4284 per cent of the weight of the meats, the average being 0.2510 per cent.

The nitrogen in the form of proteids coagulated by heat in neutral solution varied from nothing in a considerable number of samples to 0.0387 per cent in a sample of beef round (No. 1639), the average being 0.0088 per cent. As will be seen by reference to Table 117, the amounts of coagulable proteid in cold-water extracts of raw flesh was 36.5 times as great as that in meats cooked in hot water.

The average amount of albumose nitrogen in the 31 samples of boiled meats, as determined by precipitation with zinc sulphate, was 0.0463 per cent, the average amount in the 13 samples of raw meats being 0.0290 per cent. These figures seem to point to the conclusion that during the process of cooking meats in hot water the proteids undergo hydration to a certain extent. This conclusion is confirmed when the amount of albumoses in the meats cooked for three hours in hot water is compared with those cooked for five hours. Notwithstanding the fact that the average total nitrogen in the samples cooked for five hours was decidedly less than in those cooked for three hours, the former contained 0.0544 per cent of albumoses and the latter only 0.0365 per cent—that is to say, the longer the time of cooking the greater the quantity of albumoses found in the resulting cooked meat. Further confirmation is found in the fact that the amounts of nitrogen found in the meats cooked mainly at 85° C. was 0.0329 per cent, while in those cooked mainly at 100° C. it was 0.0791 per cent.

In the twelve samples of boiled meats in which the nitrogen in the form of peptones was determined by the bromin method the average amount was 0.0118 per cent.

The nitrogen soluble proteids ranged from 0.0205 per cent in a sample of beef round (No. 1780) to 0.1547 per cent in another sample (No. 1639) of the same cut, the average for the 31 samples being 0.0597 per cent. The average for the corresponding form of nitrogen in meats cooked for five hours was 0.0746 per cent, in those cooked for three hours 0.0415 per cent, and in the 13 samples of raw meats 0.3682 per cent.

While in raw meats the soluble nitrogen was about equally divided between proteid and nonproteid substances, this is certainly not the case with boiled meats, as it will be seen that the nonproteid nitrogen varies from 0.3681 to 0.9139 per cent, the average for 31 samples being 0.1913 per cent. While meats which have been cooked for five hours contain much more soluble proteid than do meats which have been cooked for three hours, the latter contain considerably more nonproteid nitrogen than the former. The average nonproteid nitrogen in 14 samples of meats which had been cooked for three hours was 0.2410 per cent, and in 17 samples cooked for five hours it was only 0.1505 per cent.

The analyses show that there is a small amount of nitrogen present as ammonia or ammonium salts in the cold-water extracts of boiled meats. The average of 26 determinations showed 0.0136 per cent nitrogen in this condition.

The average quantities of nitrogen precipitated by various reagents from cold-water extracts of boiled meats were: Bromin, 0.0241 per cent; phosphotungstic acid in a hot solution, 0.0409 per cent; phosphotungstic acid in a cold solution, 0.0635 per cent; tannin and salt, 0.0505 per cent, and Stutzer's reagent, 0.0858 per cent.

In Table 121, which follows, the nitrogen records of the meats cooked by boiling are calculated in the percentages of the total nitrogen contained in the cooked flesh.

Table 121.—*Nitrogen records of the cold-water extracts of meats cooked by boiling (results expressed in percentage of the total nitrogen of meat taken).*

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature. At beginning.	Temperature. During cooking.	Duration of cooking.	Total nitrogen in meat.	Total nitrogen in water extract.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose.)	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$.
				°C.	*°C.*	*Hrs.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1642	1640	109	Beef, round	Cold.	85	3	100	2.77	0.04	0.33	0.37	......
1754	1753	137	.....do	Cold.	85	3	100	4.80	0	.55	.55	......
			Average	Cold.	85	3	100	3.78	.02	.44	.46	......
1756	1753	139	Beef, round (browned)	Cold.	85	3	100	4.87	0	.51	.51	......
			Average Nos. 1642, 1754, and 1756	Cold.	85	3	100	4.15	.01	.46	.47	......
1746	1741	136	Beef, round (browned)	85	85	3	100	4.56	.03	.39	.42	......
1769	1764	145	Beef, round	85	85	3	100	5.83	.13	.47	.60	......
1780	1775	154	.....do	85	85	3	100	4.58	0	.34	.34	......
			Average Nos. 1769 and 1780	85	85	3	100	5.21	.07	.40	.47	......
			Average Nos. 1746, 1769, and 1780	85	85	3	100	4.99	.05	.40	.45	......
1641	1640	108	Beef, round	100	85	3	100	2.85	.61	.43	1.04	......
1744	1741	134	.....do	100	85	3	100	5.23	.11	.78	.89	......
1768	1764	144	.....do	100	85	3	100	6.63	.21	.43	.64	......
1779	1775	153	.....do	100	85	3	100	5.52	0	.53	.53	......
			Average	100	85	3	100	5.06	.23	.54	.77	......
1755	1753	138	Beef, round	Cold.	100	3	100	5.28	0	1.20	1.20	......
1757	1753	140	Beef, round (browned)	Cold.	100	3	100	5.67	0	1.34	1.34	......
			Average	Cold.	100	3	100	5.48	0	1.27	1.27	......
1743	1741	133	Beef, round	100	100	3	100	5.13	.05	.85	.90	......
1745	1741	135	Beef, round (browned)	100	100	3	100	4.86	.02	.68	.70	......
			Average	100	100	3	100	5.00	.04	.76	.80	......
			Average of all cooked 3 hours	......	......	......	100	4.90	.08	.63	.71	......
1646	1647	113	Beef, round	Cold.	65	5	100	2.63	.12	.37	.49	0.34
1645	1647	112	.....do	Cold.	85	5	100	2.97	.14	.61	.75	.30
1654	1656	116	Veal, leg	Cold.	85	5	100	3.73	.23	1.52	1.75	.13
1658	1662	118	.....do	Cold.	85	5	100	3.97	.05	.59	.64	.41
			Average Nos. 1654 and 1658	Cold.	85	5	100	3.85	.14	1.06	1.20	.27
			Average Nos. 1645, 1654, and 1658	Cold.	85	5	100	3.56	.14	.91	1.05	.28
1644	1647	111	Beef, round	100	85	5	100	3.11	.12	.55	.67	.16
1720	1722	131	.....do	100	85	5	100	4.41	.14	.34	.48	......
			Average	100	85	5	100	3.76	.13	.45	.58	......
1665	1668	121	Beef, neck	100	85	5	100	2.62	.04	.40	.44	.15
1673	1676	123	Beef, rump	100	85	5	100	6.52	.30	1.29	1.59	.28
1703	1705	125	.....do	100	85	5	100	3.47	.30	1.07	1.37	......
			Average Nos. 1673 and 1703	100	85	5	100	5.00	.30	1.18	1.48	......

TABLE 121.—*Nitrogen records of the cold-water extracts of meats cooked by boiling (results expressed in percentage of the total nitrogen of meat taken)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Total nitrogen in meat.	Total nitrogen in water extract.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$.
				At beginning.	During cooking.							
				°*C.*	°*C.*	*Hrs.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1669	1672	122	Beef, flank	100	85	5	100	2.40	0.41	1.45	1.86	0.10
1653	1656	115	Veal. leg	100	85	5	100	5.62	.32	.92	1.24	.24
1664	1662	117	.....do	100	85	5	100	4.63	.14	.72	.86	.19
			Average Nos. 1653 and 1664	100	85	5	100	5.13	.23	.82	1.05	.22
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	......	......	......	100	4.10	.22	.84	1.06	.19
1639	1637	107	Beef, round	100	100	5	100	5.47	.69	2.06	2.75	......
1643	1647	110	.....do	100	100	5	100	5.36	.43	2.06	2.49	.25
1721	1722	132	.....do	100	100	5	100	5.59	.20	1.48	1.68	......
			Average	100	100	5	100	5.47	.44	1.87	2.31	......
1704	1705	126	Beef, rump	100	100	5	100	6.86	.27	2.87	3.14	......
1652	1656	114	Veal, leg	100	100	5	100	8.07	.26	.73	.99	.33
			Average Nos. 1639, 1643, 1652, 1704, and 1721	100	100	5	100	6.27	.37	1.84	2.21	.29
			Average of all cooked 5 hours	......	......	5	100	4.56	.24	1.12	1.36	.24
			Average of all cooked 3 and 5 hours	......	......	......	100	4.71	.17	.90	1.07	.24

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Proteid nitrogen in water extract.	Nonproteid nitrogen in water extract.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen precipitated by alcohol.	Nitrogen as free ammonia.
				P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1642	1640	109	Beef, round	0.37	2.40	......	......	0.07	0.18	......	......	......
1754	1753	137	.....do	.55	4.25	......	2.66	.72	.78	1.50	......	0.29
			Average	.46	3.33	......	......	.40	.48	......	......	......
1756	1753	139	Beef, round (browned)	.51	4.36	......	.21	.62	1.08	1.51	......	.29
			Average Nos. 1642, 1754, and 1756	.47	3.68	......	......	.47	.68	......	......	......
1746	1741	136	Beef, round (browned)	.42	4.14	......	.15	.54	.87	.51	......	.23
1769	1764	145	Beef, round	.60	5.23	......	.47	.56	.59	1.61	......	.38
1780	1775	154	.....do	.34	4.24	......	.33	.26	.38	1.15	......	.35
			Average Nos. 1769 and 1780	.47	4.74	......	.40	.41	.49	1.38	......	.37
			Average Nos. 1746, 1769, and 1780	.45	4.54	......	.32	.45	.61	1.09	......	.32
1641	1640	108	Beef, round	1.04	1.81	......	......	.38	.55	......	......	......
1744	1741	134	.....do	.89	4.34	......	.82	.96	.97	.98	......	.30
1768	1764	144	.....do	.64	5.99	......	.65	.32	.82	1.65	......	.46
1779	1775	153	.....do	.53	4.99	......	.56	.49	2.18	1.52	......	.27
			Average	.77	4.29	......	[a] .68	.54	1.13	1.38	......	.34

[a] Average of 3 analyses.

TABLE 121.—*Nitrogen records of the cold-water extracts of meats cooked by boiling (results expressed in percentage of the total nitrogen of meat taken)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat	Proteid nitrogen in water extract.	Nonproteid nitrogen in water extract.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent	Nitrogen precipitated by alcohol.	Nitrogen as free ammonia.
				P. ct.	*P. ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*	*P. ct.*
1755	1753	138	Beef, round	1.20	4.08	......	0.12	1.37	1.54	2.04	......	0.39
1757	1753	140	Beef, round (browned)	1.34	4.33	......	1.45	1.51	1.56	2.30	......	.40
			Average	1.27	4.21	......	.79	1.44	1.55	2.17	......	.40
1743	1741	133	Beef, round	.90	4.23	......	.34	.96	1.16	.84	......	.33
1745	1741	135	Beef, round (browned)	.70	4.16	......	.16	.66	1.01	.87	......	.39
			Average	.80	4.20	......	.25	.81	1.09	.86	......	.36
			Average of all cooked 3 hours	.71	4.19	......	.66	.67	.98	[a] 1.37	......	[b] .34
1646	1647	113	Beef, round	.83	1.80	......	......	.59	.38	......	......	Trace
1645	1647	112	do	1.05	1.92	......	......	.60	.66	......	......	Trace
1654	1656	116	Veal, leg	1.88	1.85	0.26	.12	......	......	......	......	......
1658	1662	118	do	1.05	2.92	.57	.14	1.01	1.24	......	......	.10
			Average Nos. 1654 and 1658	1.47	2.39	.42	.28	......	......	......	......	......
			Average Nos. 1645, 1654 and 1658	1.33	2.23	.42	.28	.81	.95	......	......	.05
1644	1647	111	Beef, round	.83	2.28	......	......	.32	.42	......	......	.01
1720	1722	131	do	.48	3.93	......	.56	1.97	2.27	2.60	0.76	.15
			Average	.66	3.11	......	......	1.15	1.35	......	......	.08
1665	1668	121	Beef, neck	.59	2.03	.87	.69	.62	.60	......	......	.24
1673	1676	123	Beef, rump	1.87	4.65	.32	.86	2.18	3.13	......	......	.55
1703	1705	125	do	1.37	2.10	......	.54	.94	1.11	1.38	1.06	.34
			Average Nos. 1673 and 1703	1.62	3.38	......	.70	1.56	2.12	......	......	.45
1669	1672	122	Beef, flank	1.96	.44	.19	.80	.45	.88	......	......	0
1653	1656	115	Veal, leg	1.48	4.14	.49	.16	.85	1.14	......	......	.07
1664	1662	117	do	1.05	3.58	.60	.53	.92	.67	......	......	.44
			Average Nos. 1653 and 1664	1.27	3.86	.55	.35	.89	.91	......	......	.26
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	1.21	2 89	[b] .49	[c] .59	1.03	1.28	1.99	.91	.24
1639	1637	107	Beef, round	2.75	2.72	......	......	1.86	2.27	......	......	......
1643	1647	110	do	2.74	2.62	......	......	1.97	2.03	......	......	.01
1721	1722	132	do	1.68	3.91	......	1.89	1.09	2.00	1.83	.22	.34
			Average	2.39	3.08	......	......	1.64	2.10	......	......	.18
1704	1705	126	Beef, rump	3.14	3.72	......	2.51	3.01	3.22	2.64	3.11	.38
1652	1656	114	Veal, leg	1.32	6.75	1.39	1.19	1.46	1.89	......	......	......
			Average Nos. 1639, 1643, 1652, 1704, and 1721	2.33	3.94	......	1.86	1.88	2.28	2.24	1.67	.24
			Average of all cooked 5 hours	1.54	3.02	.59	.86	1.24	1.49	2.11	1.29	.19
			Average of all cooked 3 and 5 hours	1.17	3.55	.59	.76	.97	1.26	1.56	1.29	.26

[a] Average of 12 analyses.

[b] Average of 5 analyses.

[c] Average of 7 analyses.

It will be noted that the soluble nitrogen in the boiled meats ranged from 2.40 to 8.07 per cent of the total nitrogen contained in the cooked product, the average for the 31 samples being 4.73 per cent.

The average quantity of nitrogen of soluble compounds coagulated by heat in neutral solution was 0.17 per cent, and the average albumose nitrogen in the cold-water extracts was 0.90 per cent, which is the same as the corresponding figure for raw meats. In the 12 samples where nitrogen was precipitated by bromin from the zinc sulphate filtrate the amount found was only 0.24 per cent.

The average amount of soluble proteid nitrogen in the 31 samples was 1.17 per cent of the total nitrogen present, and the nonproteid 3.55 per cent. By reference to Table 118 it will be seen that in raw meats the proteid nitrogen is ten times greater than in cold-water extracts of boiled meats. The nitrogen in the form of ammonia or ammonium compounds made up 0.26 per cent of the total nitrogen present in the boiled meats.

The other reagents used in estimating the nitrogenous compounds in the cold-water extracts of boiled meats separated the following average amounts: Bromin, 0.59 per cent; phosphotungstic acid in a hot solution, 0.76 per cent; phosphotungstic acid in a cold solution, 1.26 per cent; tannin and salt, 0.97 per cent, and Stutzer's reagent, 1.56 per cent. For corresponding results obtained from the raw meats, see page 147.

In Table 122 the figures for the nitrogen of the boiled meats are given in percentages of the total soluble nitrogen.

TABLE 122.—*Nitrogen records of the cold water extracts of meats cooked by boiling (results expressed in percentage of the total nitrogen of the water extract).*

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Total nitrogen in meat.	Total nitrogen in water extract.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$.
				At beginning.	During cooking.							
				°C.	°C.	Hrs.	P. ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1642	1640	109	Beef, round	Cold.	85	3	5.77	100	1.56	11.83	13.39	.. ....
1754	1753	137	do	Cold.	85	3	5.88	100	0	11.37	11.37	....
			Average	Cold.	85	3	5.83	100	.78	11.60	12.38	....
1756	1753	139	Beef, round (browned)	Cold.	85	3	5.50	100	0	10.42	10.42	....
			Average Nos. 1642, 1754, and 1756	Cold.	85	3	5.72	100	.52	11.21	11.73	....
1746	1741	136	Beef, round (browned)	85	85	3	5.70	100	.69	8.60	9.29	....
1769	1764	145	Beef, round	85	85	3	5.81	100	2.21	8.00	10.21	....
1780	1775	154	do	85	85	3	6.04	100	0	7.42	7.42	....
			Average Nos. 1769 and 1780	85	85	3	5.93	100	1.11	7.71	8.82	....
			Average Nos. 1746, 1769, and 1780	......	......	......	5.85	100	.97	8.01	8.97	....

TABLE 122.—*Nitrogen records of the cold-water extracts of meats cooked by boiling (results expressed in percentage of the total nitrogen of the water extract)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Total nitrogen in meat.	Total nitrogen in water extract.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumoses).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$.
				At beginning.	During cooking.							
				°C	°C.	Hrs.	P. ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1641	1640	108	Beef, round	100	85	3	5.91	100	21.55	14.96	36.51	....
1744	1711	134	do	100	85	3	5.86	100	2.09	11.94	17.03	....
1768	1764	144	do	100	85	3	5.31	100	3.10	6.50	9.60	....
1779	1775	153	do	100	85	3	6.01	100	0	9.64	9.64	....
			Average	100	85	3	5.77	100	6.69	11.51	18.20	....
1755	1753	138	Beef, round	Cold.	100	3	5.86	100	0	22.75	22.75	....
1757	1753	140	Beef, round (browned)	Cold.	100	3	5.86	100	0	23.60	23.60	....
			Average	Cold.	100	3	5.86	100	0	23.18	23.18	....
1743	1741	133	Beef, round	100	100	3	5.83	100	1.04	16.56	17.60	....
1745	1741	135	Beef, round (browned)	100	100	3	5.56	100	.41	13.99	14.40	....
			Average	100	100	3	5.70	100	.73	15.28	16.01	....
			Average of all cooked 3 hours	......	......	3	5.78	100	2.34	12.90	15.24	....
1646	1647	113	Beef, round	Cold.	65	5	5.24	100	4.49	14.06	18.55	13.04
1645	1647	112	do	Cold.	85	5	5.24	100	4.60	20.68	25.28	10.12
1654	1656	116	Veal, leg	Cold.	85	5	5.070	100	6.18	40.75	46.93	3.38
1658	1662	118	do	Cold.	85	5	4.800	100	1.26	11.92	16.18	10.24
			Average Nos. 1654 and 1658	Cold.	85	5	4.935	100	3.72	27.81	31.56	6.81
			Average Nos. 1645, 1654, and 1658	Cold.	85	5	5.037	100	4.01	25.45	29.46	7.91
1641	1647	111	Beef, round	100	85	5	5.590	100	3.79	17.70	21.49	5.11
1720	1722	131	do	100	85	5	5.309	100	3.20	7.68	10.88	....
			Average	100	85	5	5.450	100	3.50	12.69	16.19	....
1665	1668	121	Beef, neck	100	85	5	5.039	100	1.58	15.42	17.00	5.60
1673	1676	123	Beef, rump	100	85	5	3.245	100	4.63	19.84	24.47	4.30
1703	1705	125	do	100	85	5	4.433	100	8.53	30.99	39.52	....
			Average Nos. 1673 and 1703	100	85	5	3.839	100	6.58	25.42	32.00	....
1669	1672	122	Beef, flank	100	85	5	3.210	100	17.17	60.60	77.77	4.16
1653	1656	115	Veal, leg	100	85	5	5.360	100	5.61	16.43	22.04	4.25
1664	1662	117	do	100	85	5	4.900	100	3.13	15.55	18.68	4.01
			Average Nos. 1653 and 1664	100	85	5	5.130	100	4.37	15.99	20.36	4.13
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	100	85	5	4.636	100	5.96	23.03	28.98	4.57
1639	1637	107	Beef, round	100	100	5	5.640	100	12.54	37.57	50.11	....
1643	1647	110	do	100	100	5	5.370	100	7.99	38.40	46.39	4.62
1721	1722	132	do	100	100	5	5.324	100	3.50	26.53	30.03	....
			Average	100	100	5	5.445	100	8.01	34.17	42.18	....
1704	1705	126	Beef, rump	100	100	5	4.583	100	3.94	41.85	45.79	....
1652	1656	114	Veal, leg	100	100	5	5.310	100	3.22	9.06	12.28	4.13
			Average Nos. 1639, 1643, 1652, 1704, and 1721	100	100	5	5.245	100	6.24	30.68	36.92	4.38
			Average of all cooked 5 hours	......	......	......	4.921	100	5.61	25.18	30.79	6.08
			Average of all cooked for 3 and 5 hours	......	......	......	5.315	100	4.13	19.63	23.76	6.08

TABLE 122.—*Nitrogen records of the cold-water extracts of meat cooked by boiling (results expressed in percentage of the total nitrogen of the water extract)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Proteid nitrogen in water extract.	Nonproteid nitrogen in water extract.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen percipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen precipitated by alcohol.	Nitrogen as free ammonia.
				P. ct.	*P. ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*	*P. ct.*
1642	1640	109	Beef, round	13.39	86.61	......	......	2.44	6.38	......	......	......
1754	1753	137	....do	11.37	88.63	......	55.40	14.88	16.23	31.24	......	6.16
			Average	12.38	87.62	......	......	8.66	11.31	......	......	......
1756	1753	139	Beef, round (browned)	10.42	89.58	......	4.33	12.70	22.15	31.08	......	5.94
			Average Nos. 1642, 1754, and 1756	11.73	88.27	......	29.87	10.01	14.92	31.16	......	6.05
1746	1741	136	Beef, round (browned)	9.29	90.71	......	3.20	11.87	19.04	11.21	......	5.01
1769	1764	145	Beef, round	10.21	89.79	......	8.03	9.59	10.18	27.66	......	6.52
1780	1775	154	....do	7.42	92.58	......	7.20	5.64	8.14	25.04	......	7.60
			Average Nos. 1769 and 1780	8.82	91.18	......	7.62	7.62	9.16	26.35	......	7.06
			Average Nos. 1746, 1769, and 1780	8.98	91.02	......	6.14	9.03	12.45	21.30	......	6.38
1641	1640	108	Beef, round	36.51	63.49	......	......	13.24	19.30	......	......	......
1744	1741	134	....do	17.03	82.97	......	15.59	18.27	18.53	18.79	......	5.68
1768	1764	144	....do	9.60	90.40	......	9.83	4.89	12.44	24.89	......	7.00
1779	1775	153	....do	9.64	90.36	......	10.07	8.95	39.56	27.51	......	4.94
			Average	18.20	81.80	......	[a]11.83	11.34	22.46	23.73	......	5.87
1755	1753	138	Beef, round	22.75	77.25	......	22.65	25.92	29.06	38.61	......	7.44
1757	1753	140	Beef, round (browned)	23.60	76.40	......	25.53	26.73	27.60	40.61	......	7.04
			Average	23.18	76.83	......	24.09	26.33	28.33	39.61	......	7.24
1743	1741	133	Beef, round	17.60	82.40	......	6.64	18.86	22.66	16.42	......	6.41
1745	1741	135	Beef, round (browned)	14.40	85.60	......	3.26	13.62	20.73	17.96	......	7.67
			Average	16.00	84.00	......	4.95	16.24	21.70	17.19	......	7.04
			Average of all cooked 3 hours	15.24	84.76	......	11.31	13.40	19.43	[b]25.92	......	[b]6.45
1646	1647	113	Beef, round	31.59	68.41	......	......	22.68	14.63	......	......	.14
1645	1647	112	....do	35.40	64.60	......	......	20.19	22.11	......	......	.06
1654	1656	116	Veal, leg	50.31	49.69	6.93	3.28	......	.16	......	......	......
1658	1662	118	....do	26.42	73.58	14.41	11.03	25.32	31.25	......	......	2.57
			Average Nos. 1654 and 1658	38.37	61.64	10.69	7.16	......	15.71	......	......	......
			Average Nos. 1645, 1654, and 1658	37.38	62.62	......	......	22.76	17.84	......	......	1.32
1644	1647	111	Beef, round	26.60	73.40	......	......	10.52	13.79	......	......	.17
1720	1722	131	....do	10.88	89.12	......	12.76	44.73	51.60	58.98	17.11	3.33
			Average	18.74	81.26	......	......	27.63	32.70	......	......	1.75
1665	1668	121	Beef, neck	22.60	77.40	3.32	2.65	24.34	23.05	......	......	8.99
1673	1676	123	Beef, rump	28.77	71.23	4.86	13.23	33.44	48.09	......	......	8.50
1703	1705	125	....do	39.52	60.48	......	15.63	27.15	31.97	39.78	30.47	9.64
			Average Nos. 1673 and 1703	34.15	65.86	......	14.43	30.30	40.03	......	......	9.07

[a] Average of 3 analyses.

[b] Average of 12 analyses.

TABLE 122.—*Nitrogen records of the cold-water extracts of meats cooked by boiling (results expressed in percentage of the total nitrogen of the water extract)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Proteid nitrogen in water extract.	Nonproteid nitrogen in water extract.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen precipitated by alcohol.	Nitrogen as free ammonia.
				P. ct.	*P. ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*	*P. ct.*
1669	1672	122	Beef, flank	81.93	18.07	8.06	33.55	18.47	36.67	......	......	0
1653	1656	115	Veal, leg	26.29	73.71	8.73	2.76	15.14	20.35	......	......	1.32
1664	1662	117	....do	22.69	77.31	13.00	11.37	19.91	14.63	......	......	9.43
			Average Nos. 1653 and 1664	24.49	75.51	10.87	7.07	17.53	17.49	......	......	5.38
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	32.41	67.59	[a]7.59	[b]13.14	21.21	30.02	49.38	23.79	5.17
1639	1637	107	Beef, round	50.11	49.89	......	......	34.01	41.40	......	......	......
1643	1647	110	....do	51.01	48.99	......	......	36.81	37.88	......	......	.21
1721	1722	132	....do	30.03	69.97	......	33.80	19.50	35.74	32.68	4.00	6.05
			Average	43.72	56.28	......	......	30.12	38.34	......	......	3.13
1704	1705	126	Beef, rump	45.79	51.21	......	36.53	43.85	46.93	38.51	45.31	5.47
1652	1656	114	Veal, leg	16.41	83.59	17.23	14.71	18.08	23.37	......	......	......
			Average Nos. 1639, 1643, 1652, 1704, and 1721	38.67	61.33	......	28.35	30.46	37.06	35.60	21.67	3.91
			Average of all cooked 5 hours	35.08	64.92	9.57	15.95	25.89	29.04	42.49	21.23	3.99
			Average of all cooked for 3 and 5 hours	26.12	73.88	9.57	15.13	20.06	21.70	30.06	21.23	5.13

[a] Average of 5 analyses.

[b] Average of 7 analyses.

The results given in the table show that in a considerable number of cases there was no nitrogen in the form of compounds coagulated by heat, while in other cases the quantity of nitrogen in this form reached 17.17 to 21.55 per cent, the average for the 31 samples of boiled meat being 4.13 per cent.

From 6.50 to 60.60 per cent of the soluble nitrogen of boiled meats was precipitated as albumoses, the average being 19.63 per cent. the average amounts for raw meats being 4.09 per cent. (See p. 148). These figures strikingly show the hydrolyizing action of hot water upon the proteid compounds of meats, as do also the following: In meats cooked in hot water for three hours 12.90 per cent of the soluble nitrogen existed as albumose, while in the meats cooked in hot water for five hours the amount was 25.18 per cent. In meats cooked chiefly at 85° C. it was found that 17.19 per cent, and in those cooked mainly at 98.5° C. 25.59 per cent of the soluble nitrogen was in the form of albumoses.

In the 12 samples of boiled meats the average quantity of nitrogen precipitated by bromin in the filtrate from the zinc sulphate precipitate equaled 6.08 per cent of the total soluble nitrogen. The soluble proteid nitrogen ranged from 7.42 to 81.93 per cent, averaging for the 31 samples 26.12 per cent, and the nitrogen in the form of ammonium compounds was 5.13 per cent.

From the cold-water solutions of meats cooked by contact with hot water the reagents mentioned below precipitated the following amounts of nitrogen expressed in terms of the total soluble nitrogen: Bromin, 9.57 per cent; phosphotungstic acid in the hot solution, 15.13 per cent; phosphotungstic acid in the cold solution, 24.70 per cent; tannin and salt, 20.06 per cent, and Stutzer's reagent 30.06 per cent.

FORMS OF NITROGEN IN MEATS COOKED BY ROASTING, BROILING, SAUTÉING, AND FRYING.

In the following pages the data regarding the different forms of nitrogen existing in meats cooked by roasting, broiling, sautéing, and frying are summarized, Table 123 showing the data calculated on the basis of the total weight of the sample used.

TABLE 123.—*Nitrogen records of the cold-water extracts of meats cooked by roasting, broiling, sautéing, and frying (results expressed in percentage of meat taken).*

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat and method of cooking.	Total nitrogen in meat.	Total nitrogen in water extract.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$ precipitate.	Proteid nitrogen in water extract.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1770	1764	146	Beef, round, pot roast	5.972	0.4978	0.0019	0.0483	0.0502	....	0.0502
1781	1775	155	do	5.891	.4212	.0273	.0395	.0668	....	.0668
			Average	5.932	.4595	.0146	.0439	.0585	....	.0585
1771	1764	147	Beef, round, roast	3.870	.5567	.0915	.0279	.1194	....	.1194
1782	1775	156	do	4.011	.4972	.1732	.0236	.1968	....	.1968
			Average	3.941	.5270	.1324	.0258	.1582	....	.1582
1660	1662	120	Veal, leg, roast	4.220	.4956	.0031	.0426	.0457	0.0206	.0663
			Average Nos. 1660, 1771, and 1782	4.034	.5165	.0893	.0314	.1207	....	.1275
1778	1775	152	Beef, round, gas broiled	4.088	.5753	.1073	.0253	.1326	....	.1326
1766	1764	142	Beef, round, pan broiled	4.037	.6863	.1806	.0380	.2186	....	.2186
1777	1775	151	do	4.435	.5693	.0648	.0288	.0936	....	.0936
			Average Nos. 1766, 1777, and 1778	4.236	.6278	.1227	.0334	.1561	....	.1561
1674	1676	124	Beef, rump, pan broiled	3.785	.3873	.0086	.0278	.0364	.0073	.0437
1659	1662	119	Veal, leg, pan broiled	4.700	.4939	.0132	.0370	.0502	.0176	.0678
			Average Nos. 1659, 1674, 1766, and 1777.	4.239	.5342	.0668	.0329	.0997	.0125	.1059
1765	1764	141	Beef, round, sautéed	4.044	.6079	.1336	.0315	.1651	....	.1651
1776	1775	150	do	4.083	.5556	.0896	.0260	.1156	....	.1156
			Average	4.064	.5818	.1116	.0288	.1404	....	.1404

TABLE 123.—*Nitrogen records of the cold-water extracts of meats cooked by roasting, broiling, sautéing, and frying (results expressed in percentage of meat taken)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat and method of cooking	Total nitrogen in meat.	Total nitrogen in water extract.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose)	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$ precipitate.	Proteid nitrogen in water extract
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct*	*Per ct.*
1767	1764	143	Beef, round, fried	4.934	0.6052	0.0526	0.0330	0.0856	....	0.0856
			Average of all beef samples	4.468	.5418	.0846	.0318	.1164	....	.1171
			Average of all veal samples	4.460	.4948	.0082	.0398	.0480	0.0191	.0671
			Average of all beef and veal samples	4.467	.5346	.0728	.0330	.1059	....	.1094

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat and method of cooking.	Nonproteid nitrogen in water extract.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen as free ammonia.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1770	1764	146	Beef, round, pot roast	0.4476	....	0.0552	0.0563	0.0709	0.1366	0.0222
1781	1775	155	....do	.3544	....	.0443	.0486	.0584	.1128	.0277
			Average	.4010	....	.0498	.0525	.0647	.1247	.0250
1771	1764	147	Beef, round, roast	.4373	....	.1122	.1148	.1259	.1832	.0159
1782	1775	156	....do	.3004	....	.1090	.1000	.0978	.1631	.0206
			Average	.3689	....	.1106	.1074	.1119	.1732	.0183
1660	1662	120	Veal, leg, roast	.4293	0.0249	.0305	.0398	.0283	....	.0316
			Average Nos. 1660, 1771, and 1782	.3890	....	.0839	.0849	.0840	.1732	.0227
1778	1775	152	Beef, round, gas broiled	.4427	....	.1476	.1333	.1383	.2041	.0197
1766	1764	142	Beef, round, pan broiled	.4677	....	.2237	.2077	.2218	.2562	.0183
1777	1775	151	....do	.4757	....	.1011	.0840	.0995	.1610	.0213
			Average Nos. 1766, 1777, and 1778	.4717	....	.1624	.1459	.1607	.2086	.0198
1674	1676	124	Beef, rump, pan broiled	.3436	.0245	.0389	.0008	.0204	....	.0185
1659	1662	119	Veal, leg, pan broiled	.4261	.0401	.0449	.0259	.0084	....	.0246
			Average Nos. 1659, 1674, 1766, and 1777	.4283	.0323	.1022	.0796	.0876	.2086	.0207
1765	1764	141	Beef, round, sautéed	.4428	....	.1678	.1653	.1655	.2114	.0166
1776	1775	150	....do	.4400	....	.1141	.1149	.1238	.1799	.0198
			Average	.4414	....	.1410	.1401	.1447	.1957	.0182
1767	1764	143	Beef, round, fried	.5196	....	.0909	.0933	.1007	.1715	.0202
			Average of all beef samples	.4247	....	.1095	.1017	.1112	[a].1780	.0201
			Average of all veal samples	.4277	....	.0377	.0329	.0184	....	.0281
			Average of all beef and veal samples	.4252	.0298	.0985	.0911	.0969	.1780	.0213

[a] Average of 10 analyses.

Upon examining the data it will be seen that the total nitrogen in meats cooked by dry heat varied from 3.785 per cent in pan broiled beef rump (sample No. 1674) to 5.972 per cent in a beef round pot roast (sample No. 1770), the average being 4.467 per cent.

The total nitrogen soluble in cold water was 0.3873 to 0.6863 per cent, the average being 0.5346 per cent.

The nitrogen in the form of soluble proteids coagulated by heat ranged from 0.0019 to 0.1806 per cent, the average being 0.0728 per cent.

The average amount of albumose nitrogen in the cold-water extracts was 0.0330 per cent, the soluble proteid nitrogen 0.0437 to 0.2186 per cent, the average being 0.1094 per cent, and the non-proteid nitrogen 0.3004 to 0.5196 per cent, the average being 0.4252 per cent.

The results of the analyses reported show that there is a small amount of nitrogen present as ammonium salts in the cold-water extracts of meats cooked by dry heat, the average for the thirteen determinations being 0.0213 per cent.

The other reagents used to separate the nitrogenous constituents of the cold-water extracts of meats cooked by dry heat gave results as follows: Bromin, 0.0298 per cent; phosphotungstic acid in a hot solution, 0.0985 per cent; phosphotungstic acid in a cold solution, 0.0969 per cent; tannin and salt, 0.0911 per cent, and Stutzer's reagent 0.1780 per cent.

In the case of raw as compared with fried meat (veal cutlet), Offer and Rosenquist[a] report 3.4 per cent total nitrogen and 0.53 per cent nitrogen of extractives in the raw material and 4.38 per cent and 0.506 per cent, respectively, in the cutlet fried in a little butter.

In Table 124 the nitrogen values for the meats cooked by dry heat in the Illinois experiments are given in the form of percentages of the total nitrogen content of the cooked flesh.

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[a] Berlin. Klin. Wchnschr., 36 (1899), p. 1086.

TABLE 124.—*Nitrogen records of the cold-water extracts of meats cooked by roasting, broiling, sautéing, and frying (results expressed in percentage of total nitrogen of meat taken).*

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat and method of cooking.	Total nitrogen in meat.	Total nitrogen in water extract.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$ precipitate.	Proteid nitrogen in water extract.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1770	1764	146	Beef, round, pot roast....	100	8.34	0.03	0.81	0.84	....	0.84
1781	1775	155	.....do..............	100	7.15	.46	.67	1.13	....	1.13
			Average.............	100	7.75	.25	.71	.99	....	.99
1771	1764	157	Beef, round, roast........	100	14.38	2.36	.72	3.08	....	3.08
1782	1775	156	.....do....................	100	12.40	4.32	.59	4.91	....	4.91
			Average.............	100	13.39	3.34	.66	4.00	....	4.00
1660	1662	120	Veal, leg, roast...........	100	11.74	.07	1.01	1.08	0.49	1.57
			Average Nos. 1660, 1771, and 1782.....	100	12.84	2.25	.77	3.02	....	3.19
1778	1775	152	Beef, round, gas broiled...	100	14.07	2.62	.62	3.24	....	3.24
1766	1764	142	Beef, round, pan broiled..	100	17.00	4.47	.94	5.41	....	5.41
1777	1775	151	.....do.....................	100	12.81	1.46	.65	2.11	....	2.11
			Average Nos. 1766 and 1777..........	100	14.92	2.97	.80	3.76	....	3.76
1674	1676	124	Beef, rump, pan broiled...	100	10.23	.23	.73	.96	.19	1.15
1659	1662	119	Veal, leg, pan broiled.....	100	10.51	.28	.79	1.07	.37	1.44
			Average Nos. 1659, 1674, 1766, and 1777.	100	12.64	1.61	.78	2.39	.28	2.53
1765	1764	141	Beef, round, sautéed......	100	15.03	3.30	.78	4.08	....	4.08
1776	1775	150	.....do....................	100	13.61	2.19	.61	2.83	....	2.83
			Average.............	100	14.32	2.75	.71	3.46	....	3.46
1767	1764	143	Beef, round, fried.........	100	12.27	1.07	.67	1.74	....	1.74
			Average of all beef samples...........	100	12.48	2.05	.71	2.76	.19	2.78
			Average of all veal samples...........	100	11.13	.18	.90	1.08	.43	1.51
			Average of all beef and veal samples..	100	12.27	1.76	.74	2.50	....	2.58

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat and method of cooking.	Nonproteid nitrogen in water extract.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold.)	Nitrogen precipitated by Stutzer's reagent.	Nitrogen as free ammonia.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1770	1764	146	Beef, round, pot roast....	7.50	....	0.92	0.94	1.19	2.29	0.37
1781	1775	155	.....do.....................	6.02	....	.75	.83	.99	1.91	.47
			Average.......... ...	6.76	....	.84	.89	1.09	2.10	.42
1771	1764	157	Beef, round, roast........	11.30	....	2.90	2.96	3.25	4.73	.41
1782	1775	156	.....do.....................	7.49	....	2.72	2.50	2.44	4.07	.51
			Average.............	9.39	....	2.81	2.73	2.85	4.40	.46

TABLE 124.—*Nitrogen records of the cold-water extracts of meats cooked by roasting, broiling, sautéing, and frying (results expressed in percentage of total nitrogen of meat taken)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat and method of cooking.	Nonproteid nitrogen in water extract.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen as free ammonia.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1660	1662	120	Veal, leg, roast	10.17	0.59	0.72	0.94	0.67	....	0.75
			Average Nos. 1660, 1771, and 1782	9.65	....	2.11	2.13	2.12	....	.56
1778	1775	152	Beef, round, gas broiled	10.83	....	3.61	3.26	3.38	4.99	.48
1766	1764	142	Beef, round, pan broiled	11.59	....	5.54	5.15	5.49	6.35	.45
1777	1775	151	do	10.73	....	2.28	1.90	2.25	3.63	.48
			Average Nos. 1766 and 1777	11.16	....	3.91	3.53	3.87	4.99	.47
1674	1676	124	Beef, rump, pan broiled	9.08	0.65	1.03	.02	.54	....	.49
1659	1662	119	Veal leg, pan broiled	9.07	.85	.96	.55	.18	....	.52
			Average Nos. 1659, 1674, 1766, and 1777	10.11	....	2.45	1.91	2.12	....	.49
1765	1764	141	Beef, round, sautéed	10.95	....	4.15	4.09	4.09	5.23	.41
1776	1775	150	do	10.78	....	2.79	2.82	3.03	4.41	.49
			Average	10.86	....	3.47	3.46	3.56	4.82	.45
1767	1764	143	Beef, round, fried	10.53	....	1.84	1.89	2.04	3.48	.41
			Average of all beef samples	9.71	....	2.59	2.40	2.61	4.11	.45
			Average of all veal samples	9.62	.72	.84	.75	.43	....	.64
			Average of all beef and veal samples	9.70	.70	2.32	2.15	2.27	[a] 4.11	.48

[a] Average of 11 analyses.

The soluble nitrogen found in meats cooked by dry heat forms 7.15 to 17 per cent of the total nitrogen contained in the cooked meat, the average being 12.27 per cent.

The average quantity of nitrogen of compounds coagulated by heat in neutral solution was 1.76 per cent; the average albumose nitrogen, 0.74 per cent; the soluble proteid nitrogen, 2.58 per cent; the nonproteid nitrogen, 6.02 to 11.59 per cent, the average being 9.70 per cent, and the nitrogen in the form of ammonia or ammonium compounds 0.48 per cent.

The other reagents employed to determine the nitrogen compounds gave the following average results: Bromin, 0.70 per cent; phosphotungstic acid in a hot solution, 2.32 per cent; phosphotungstic acid in a cold solution, 2.27 per cent; tannin and salt, 2.15 per cent, and Stutzer's reagent, 4.11 per cent.

In Table 125 the data for the nitrogen of the meats cooked by dry heat are given as percentages of the total soluble nitrogen.

TABLE 125.—*Nitrogen records of the cold-water extracts of meats cooked by roasting, broiling, sautéing, and frying (results expressed in percentage of total nitrogen in water extract).*

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat and method of cooking.	Total nitrogen in meat.	Total nitrogen in water extract.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$ precipitate.	Proteid nitrogen in water extract.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1770	1764	146	Beef, round, pot roast....	5.972	100	0.38	9.70	10.08	....	10.08
1781	1775	155	.....do.....................	5.891	100	6.48	9.38	15.86	....	15.86
			Average.............	5.932	100	3.43	9.54	12.97	....	12.97
1771	1764	147	Beef, round, roast.........	3.870	100	16.44	5.01	21.45	....	21.45
1782	1775	156	.....do.....................	4.011	100	34.83	4.75	39.58	....	39.58
			Average.............	3.941	100	25.64	4.88	30.52	....	30.52
1660	1662	120	Veal, leg, roast............	4.220	100	.63	8.59	9.22	4.16	13.38
			Average Nos. 1660, 1771, and 1782.....	4.034	100	17.30	6.12	23.42	....	24.80
1778	1775	152	Beef, round, gas broiled..	4.088	100	18.65	4.40	23.05	....	23.05
1766	1764	142	Beef, round, pan broiled..	4.037	100	26.31	5.54	31.85	....	31.85
1777	1775	151	.....do.....................	4.435	100	11.38	5.06	16.44	....	16.44
			Average Nos. 1766 and 1777...........	4.236	100	18.85	5.30	24.15	....	24.15
1674	1676	124	Beef, rump, pan broiled...	3.790	100	2.22	7.18	9.40	1.88	11.28
1659	1662	119	Veal, leg, pan broiled.....	4.700	100	2.67	7.49	10.16	3.56	13.72
			Average Nos. 1659, 1674, 1766, and 1777	4.241	100	10.65	6.32	16.96	....	18.32
1765	1764	141	Beef, round, sautéed......	4.044	100	21.98	5.18	27.16	....	27.16
1776	1775	150	.....do.....................	4.083	100	16.13	4.68	20.81	....	20.81
			Average.............	4.064	100	19.06	4.93	23.99	....	23.99
1767	1764	143	Beef, round, fried.........	4.934	100	8.69	5.45	14.14	....	14.14
			Average of all beef samples...........	4.469	100	14.86	6.03	20.89	1.88	21.06
			Average of all veal samples...........	4.460	100	1.65	8.04	9.69	3.86	13.55
			Average of all beef and veal samples..	4.468	100	12.83	6.34	19.18	....	19.91

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat and method of cooking.	Nonproteid nitrogen in water extract.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent	Nitrogen as free ammonia.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1770	1764	146	Beef, round, pot roast....	89.92	....	11.09	11.30	14.24	27.44	4.46
1781	1775	155	.....do.....................	84.14	....	10.52	11.54	13.87	26.78	6.58
			Average.............	87.03	....	10.81	11.42	14.06	27.11	5.52
1771	1764	147	Beef, round, roast.........	78.55	....	20.15	20.62	22.61	32.91	2.86
1782	1775	156	.....do.....................	60.42	....	21.92	20.11	19.67	32.80	4.14
			Average.............	69.48	....	21.04	20.37	21.14	32.86	3.50

TABLE 125.—*Nitrogen records of the cold-water extracts of meats cooked by roasting, broiling, sautéing, and frying (results expressed in percentage of total nitrogen in water extract)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat and method of cooking.	Nonproteid nitrogen in water extract.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen as free ammonia.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1660	1662	120	Veal, leg, roast	86.62	5.02	6.15	8.03	5.71	....	6.37
			Average Nos. 1660, 1771, and 1782	75.20	....	16.07	16.25	16.00	....	4.46
1778	1775	152	Beef, round, gas broiled	76.95	....	25.66	23.17	24.04	35.48	3.42
1766	1764	142	Beef, round, pan broiled	68.15	....	32.59	30.26	32.32	37.34	2.66
1777	1775	151	....do	83.56	....	17.76	14.76	17.48	28.28	3.74
			Average Nos. 1766 and 1777	75.85	....	25.18	22.51	24.90	32.81	3.20
1674	1676	124	Beef, rump, pan broiled	88.72	6.33	10.05	.21	5.27	....	4.77
1659	1662	119	Veal, leg, pan broiled	86.28	8.12	9.09	5.25	1.70	....	4.98
			Average Nos. 1659, 1674, 1766, and 1777	81.68	....	17.37	12.62	14.19	....	4.04
1765	1764	141	Beef, round, sautéed	72.84	....	27.60	27.19	27.23	34.78	2.73
1776	1775	150	....do	79.19	....	20.54	20.68	22.28	32.38	3.56
			Average	76.02	....	24.07	23.94	24.76	33.58	3.15
1767	1764	143	Beef, round, fried	85.86	....	15.02	15.42	16.64	28.34	3.34
			Average of all beef samples	78.94	....	19.35	17.75	19.60	31.65	3.84
			Average of all veal samples	86.45	....	7.62	6.64	3.71	....	5.68
			Average of all beef and veal samples	80.09	6.49	17.55	16.04	17.16	[a]31.65	4.12

[a] Average of 11 analyses.

The data summarized above show that 0.38 to 34.83 per cent of the soluble nitrogen of meats cooked by dry heat exists in the form of coagulable compounds, the average amount being 12.83 per cent. The nitrogen present as albumoses was 4.40 to 9.70 per cent, averaging 6.34 per cent.

The nonproteid nitrogen ranged from 60.42 to 89.92 per cent, averaging 80.09 per cent, and the nitrogen present in the form of ammonium compounds was 4.12 per cent of the total soluble nitrogen.

From the cold-water solutions of meats cooked by dry heat the reagents mentioned below precipitated the following amounts of nitrogen: Bromin, 6.49 per cent; phosphotungstic acid in a hot solution, 17.55 per cent; phosphotungstic acid in a cold solution, 17.16 per cent; tannin and salt, 16.04 per cent; and Stutzer's reagent, 31.65 per cent.

THE LOSSES INVOLVED IN THE BOILING AND STEWING OF MEATS.

It is interesting to consider the data regarding the kind and amount of losses sustained when meat is boiled and stewed.

The following table summarizes the results of all such experiments reported in the present bulletin, arranged according to the length of the cooking period, the method of cooking, and the kind of meat used:

TABLE 126.—*Summary of the losses involved in the cooking of meats in water.*

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Amount used.	Fat in cooked meat.	Method of cooking. Temperature. At beginning.	Method of cooking. Temperature. During cooking.	Method of cooking. Duration of cooking.
			Grams.	*Per cent.*	°*C.*	°*C.*	*Hours.*
1642	109	Beef, round, 1-inch cubes	1,000	3.93	Cold.	85	3
1754	137	Beef, round, 2-inch cubes	900	6.80	Cold.	85	3
		Average		5.37	Cold.	85	3
1756	139	Beef, round, browned, 2-inch cubes.	900	8.00	Cold.	85	3
		Average Nos. 1642, 1754, and 1756		6.24	Cold.	85	3
1746	136	Beef, round, browned, 2-inch cubes.	1,000	7.12	85	85	3
1769	145	Beef, round, 2-inch cubes	1,074.83	6.87	85	85	3
1780	154	do	1,052.17	6.62	85	85	3
		Average Nos. 1769 and 1780		6.75	85	85	3
		Average Nos. 1746, 1769, and 1780		6.87	85	85	3
1641	108	Beef, round, 1-inch cubes	1,000	4.38	100	85	3
1744	134	Beef, round, 2-inch cubes	1,000	4.83	100	85	3
		Average		4.61	100	85	3
1768	144	Beef, round, 1 piece	1,027.72	7.51	100	85	3
1779	153	do	1,098.31	7.88	100	85	3
		Average		7.70	100	85	3
		Average Nos. 1641, 1744, 1768, and 1779		6.15	100	85	3
1755	138	Beef, round, 2-inch cubes	900	7.35	Cold.	100	3
1757	140	Beef, round, browned, 2-inch cubes.	900	6.83	Cold.	100	3
		Average		7.09	Cold.	100	3
1743	133	Beef, round, lean, 2-inch cubes	1,000	5.06	100	100	3
1745	135	Beef, round, lean, browned, 2-inch cubes	1,000	7.74	100	100	3
		Average		6.40	100	100	3
		Average of all cooked 3 hours.		6.49			3
1646	113	Beef, round, ¾-inch cubes	1,000	5.57	Cold.	65	5
1645	112	do	1,000	5.23	Cold.	85	5
1654	116	Veal, leg, 1-inch cubes	1,000	.97	Cold.	85	5
1658	118	do	1,000	5.58	Cold.	85	5
		Average Nos. 1654 and 1658		3.28	Cold.	85	5
		Average Nos. 1645, 1654, and 1658		3.93	Cold.	85	5
1644	111	Beef, round, ¾-inch cubes	1,000	5.75	100	85	5
1720	131	Beef, round, 1-inch cubes	1,000	11.61	100	85	5
		Average		8.68	100	85	5

TABLE 126.—*Summary of the losses involved in the cooking of meats in water*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Amount used.	Fat in cooked meat.	Method of cooking. Temperature. At beginning.	Method of cooking. Temperature. During cooking.	Method of cooking. Duration of cooking.
			Grams.	*Per cent.*	*°C.*	*°C.*	*Hours.*
1665	121	Beef, neck, ¾-inch cubes	700	13.68	100	85	5
1673	123	Beef, rump, 1-inch cubes	1,000	42.03	100	85	5
1703	125	.....do	1,000	23.36	100	85	5
		Average Nos. 1673 and 1703	....	32.70	100	85	5
1669	122	Beef, flank, fat, ¾-inch cubes	1,000	34.16	100	85	5
1653	115	Veal, leg, 1-inch cubes	1,000	1.31	100	85	5
1664	117	.....do	1,000	7.77	100	85	5
		Average Nos. 1653 and 1664	....	4.54	100	85	5
		Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	....	17.46	100	85	5
1639	107	Beef, round, 1-inch cubes	1,000	....	100	100	5
1643	110	Beef, round, ¾-inch cubes	1,000	5.66	100	100	5
1721	132	Beef, round, 1-inch cubes	1,000	9.01	100	100	5
		Average	....	7.34	100	100	5
1704	126	Beef, rump, 1-inch cubes	1,000	16.07	100	100	5
1652	114	Veal, leg, 1-inch cubes	1,000	1.59	100	100	5
		Average Nos. 1639, 1643, 1652, 1704, and 1721	....	8.08	100	100	5
		Average of all cooked 5 hours	....	11.84	....	....	5
		Average of all cooked 3 and 5 hours	....	9.34	....	....	....

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Nutrients in the broth expressed in percentages of total amounts in uncooked meat. Water.	Proteid.	Organic extractives. Nitrogenous.	Organic extractives. Non-nitrogenous.	Fat.	Ash.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1642	109	Beef, round, 1-inch cubes	58.09	7.87	82.07	82.19	22.60	74.54
1754	137	Beef, round, 2-inch cubes	58.56	2.79	67.33	70.65	19.17	61.49
		Average	58.33	5.33	74.70	76.42	20.89	68.02
1756	139	Beef, round, browned, 2-inch cubes	54.19	1.66	66.84	71.10	11.24	61.40
		Average Nos. 1642, 1754, and 1756	56.95	4.11	72.08	74.65	17.68	65.81
1746	136	Beef, round, browned, 2-inch cubes	55.76	1.78	67.23	68.31	28.95	60.80
1769	145	Beef, round, 2-inch cubes	57.97	1.29	59.12	63.41	10.43	51.14
1780	154	.....do	....	1.29	63.48	64.88	....	54.00
		Average Nos. 1769 and 1780	....	1.29	61.30	64.15	....	52.57
		Average Nos. 1746, 1769, and 1780	....	1.45	63.28	65.53	....	55.31
1641	108	Beef, round, 1-inch cubes	57.18	3.21	85.80	84.94	20.65	73.93
1744	134	Beef, round, 2-inch cubes	57.42	1.71	66.92	66.89	10.66	60.79
		Average	57.30	2.46	76.36	75.92	15.66	67.36
1768	144	Beef, round, 1 piece	49.23	1.03	52.19	47.94	3.52	45.50
1779	153	.....do	58.37	.93	58.56	60.30	8.03	52.65
		Average	53.80	.98	55.38	54.12	5.78	49.08
		Average Nos. 1641, 1744, 1768, and 1779	55.55	1.72	65.87	65.02	10.72	58.22

TABLE 126.—*Summary of the losses involved in the cooking of meats in water*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Nutrients in the broth expressed in percentages of total amounts in uncooked meats.					
			Water.	Proteid.	Organic extractives.		Fat.	Ash.
					Nitrogenous.	Non-nitrogenous.		
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1755	138	Beef, round, 2-inch cubes	57.91	2.95	69.11	68.73	29.04	62.43
1757	140	Beef, round, browned, 2-inch cubes	57.04	1.89	67.20	68.37	14.71	62.24
		Average	57.48	2.42	68.16	68.55	21.88	62.34
1743	133	Beef, round, lean, 2-inch cubes	56.89	2.02	67.76	66.07	14.14	60.51
1745	135	Beef, round, lean, browned, 2-inch cubes	54.60	2.25	66.97	70.64	36.35	58.22
		Average	55.75	2.14	67.37	68.36	25.25	59.37
		Average of all cooked 3 hours.	56.40	2.33	67.19	68.17	17.66	59.97
1646	113	Beef, round, ¾-inch cubes	54.09	4.88	85.24	85.16	18.64	70.96
1645	112	....do	59.74	4.56	86.01	85.38	30.24	72.09
1654	116	Veal, leg, 1-inch cubes	48.30	5.25	81.64	66.88	24.83	62.40
1658	118	....do	50.94	5.75	75.77	75.24	13.43	65.12
		Average Nos. 1654 and 1658	49.62	5.50	78.71	71.06	19.13	63.76
		Average Nos. 1645, 1654, and 1658	52.99	5.19	81.14	75.83	22.83	66.74
1644	111	Beef, round, ¾-inch cubes	57.66	3.02	81.21	79.82	21.79	65.64
1720	131	Beef, round, 1-inch cubes	56.84	2.35	72.55	94.15	16.48	69.46
		Average	57.25	2.69	76.88	86.99	19.14	67.55
1665	121	Beef, neck, ¾-inch cubes	....	....	....	....	11.93	72.15
1673	123	Beef, rump, 1-inch cubes	52.16	3.91	66.70	75.53	18.95	70.10
1703	125	....do	55.00	2.68	83.30	83.56	14.50	69.88
		Average Nos. 1673 and 1703	53.58	3.30	75.00	79.55	16.73	69.99
1669	122	Beef, flank, fat, ¾-inch cubes	39.25	4.76	95.25	86.11	21.31	72.23
1653	115	Veal, leg, 1-inch cubes	48.92	2.62	67.46	65.68	6.86	58.48
1664	117	....do	50.78	3.52	70.13	67.01	6.73	61.23
		Average Nos. 1653 and 1664	49.85	3.07	68.80	66.35	6.80	59.86
		Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720.	51.51	3.27	76.66	78.84	14.82	67.40
1639	107	Beef, round, 1-inch cubes	56.41	2.70	77.35	66.00	....	60.88
1643	110	Beef, round, ¾-inch cubes	55.41	3.34	78.42	77.78	21.48	61.17
1721	132	Beef, round, 1-inch cubes	56.29	3.86	71.16	82.25	18.64	63.07
		Average	56.04	3.30	75.64	75.34	20.06	61.71
1704	126	Beef, rump, 1-inch cubes	54.42	6.09	71.30	69.78	25.36	57.83
1652	114	Veal, leg, 1-inch cubes	49.78	3.59	50.19	49.23	6.74	45.98
		Average Nos. 1639, 1643, 1652, 1704, and 1721	54.46	3.92	69.68	69.01	18.06	57.79
		Average of all cooked 5 hours	52.87	3.93	75.85	75.60	17.37	64.66
		Average of all cooked 3 and 5 hours	54.45	3.18	71.81	72.13	17.50	62.55

Table 126.—*Summary of the losses involved in the cooking of meats in water*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Nutrients in broth expressed in percentages of total weight of the uncooked meat.						
			Water.	Proteid.	Organic extractives.		Fat.	Ash.	Total solid matter.
					Nitrogenous.	Non-nitrogenous.			
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1642	109	Beef, round, 1-inch cubes....	42.97	1.56	1.02	1.34	0.59	0.77	48.25
1754	137	Beef, round, 2-inch cubes....	42.54	.54	.86	1.06	.86	.60	46.46
		Average...............	42.76	1.05	.94	1.20	.73	.69	47.37
1756	139	Beef, round, browned, 2-inch cubes......................	38.98	.32	.87	1.06	.58	.61	42.42
		Average Nos. 1642, 1754, and 1756	41.50	.81	.92	1.15	.68	.66	45.72
1746	136	Beef, round, browned, 2-inch cubes......................	39.73	.35	.84	1.10	1.62	.61	44.25
1769	145	Beef, round, 2-inch cubes....	42.57	.25	.75	.83	.44	.52	45.36
1780	154	.....do......................	....	.25	.73	.90	....	.53	....
		Average Nos. 1769 and 1780.................	....	.25	.74	.87	....	.53	....
		Average Nos. 1746, 1769, and 1780............	....	.28	.77	.94	....	.55	....
1641	108	Beef, round, 1-inch cubes....	42.12	.64	1.06	1.36	.61	.76	46.55
1744	134	Beef, round, 2-inch cubes....	42.38	.33	.87	1.19	.31	.61	45.69
		Average...............	42.25	.49	.97	1.28	.46	.69	46.14
1768	144	Beef, round, 1 piece.........	35.50	.20	.67	.73	.17	.46	37.73
1779	153	.....do......................	42.00	.19	.73	.87	.38	.52	44.69
		Average...............	38.75	.20	.70	.80	.28	.49	41.22
		Average Nos. 1641, 1744, 1768, and 1779........	40.50	.34	.83	1.04	.37	.59	43.67
1755	138	Beef, round, 2-inch cubes....	41.52	.57	.89	1.06	1.62	.63	46.29
1757	140	Beef, round, browned, 2-inch cubes......................	41.29	.37	.89	1.08	.65	.64	44.92
		Average...............	41.41	.47	.89	1.07	1.14	.64	45.62
1743	133	Beef, round, lean, 2-inch cubes	41.71	.39	.89	1.11	.46	.62	45.18
1745	135	Beef, round, lean, browned, 2-inch cubes...............	38.57	.43	.82	1.07	2.48	.57	43.94
		Average...............	40.14	.41	.86	1.09	1.47	.60	44.56
		Average of all cooked 3 hours..............	40.92	.46	.85	1.05	.83	.61	44.76
1646	113	Beef, round, ¾-inch cubes....	40.68	.91	.92	1.19	.70	.74	45.14
1645	112	.....do......................	44.72	.80	.99	1.27	1.14	.72	49.64
1654	116	Veal, leg, 1-inch cubes.......	37.61	1.01	.76	1.14	.19	.62	41.33
1658	118	.....do......................	38.60	1.02	.79	.96	.50	.63	42.50
		Average Nos. 1654 and 1658.................	38.11	1.02	.78	1.05	.35	.63	41.92
		Average Nos. 1645, 1654, and 1658	40.31	.94	.85	1.12	.61	.66	44.49
1644	111	Beef, round, ¾-inch cubes....	42.72	.56	.92	1.20	.85	.70	46.95
1720	131	Beef, round, 1-inch cubes....	40.20	.42	.95	1.34	1.26	.64	44.81
		Average...............	41.46	.49	.94	1.27	1.06	.67	45.88
1665	121	Beef, neck, ¾-inch cubes.....	....	2.09	....	....	1.02	.67	....
1673	123	Beef, rump, 1-inch cubes....	26.90	.51	.61	.86	6.32	.50	35.70
1703	125	.....do......................	35.18	.45	.86	1.03	2.36	.59	40.47
		Average Nos. 1673 and 1703.................	31.04	.48	.74	.95	4.34	.55	38.09

TABLE 126.—*Summary of the losses involved in the cooking of meats in water*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Nutrients in broth expressed in percentages of total weight of the uncooked meat.						
			Water.	Proteid.	Organic extractives		Fat.	Ash.	Total solid matter.
					Nitrogenous.	Non-nitrogenous.			
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct*	*Per ct.*
1669	122	Beef, flank, fat, ¾-inch cubes.	21.03	0.70	0.56	0.74	6.48	0.44	29.95
1653	115	Veal, leg, 1-inch cubes	37.73	.51	.85	1.13	.06	.62	40.90
1664	117	.....do........................	37.69	.64	.78	.91	.33	.62	40.97
		Average Nos. 1653 and 1664..................	37.71	.58	.82	1.02	.20	.62	40.94
		Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720........	34.49	.74	.79	1.03	2.34	.60	39.97
1639	107	Beef, round, 1-inch cubes..	41.80	.52	.89	1.25	.74	.67	45.87
1643	110	Beef, round, ¾-inch cubes....	41.18	.62	.88	1.09	.85	.64	45.26
1721	132	Beef, round, 1-inch cubes....	40.44	.71	.88	1.27	1.14	.59	45.03
		Average...............	41.14	.62	.88	1.20	.91	.63	45.39
1704	126	Beef, rump, 1-inch cubes....	37.14	1.01	.75	.94	3.09	.53	43.46
1652	114	Veal, leg, 1-inch cubes.......	37.96	.68	.67	.96	.07	.51	40.85
		Average Nos. 1639, 1643, 1652, 1704, and 1721...	39.70	.71	.81	1.10	1.18	.59	44.09
		Average of all cooked 5 hours..............	37.60	.78	.82	1.08	1.59	.61	42.43
		Average of all cooked 3 and 5 hours........	39.09	.63	.83	1.07	1.24	.61	43.47

In the thirty-one experiments here reported with meat cooked in hot water the total losses in weight varied from 29.95 to 49.64 per cent of the total weight of the fresh meat used, the average being 43.47 per cent. The smallest loss was observed in experiment No. 122, in which a cut of fat beef flank was cooked for ten minutes in boiling water, and then at a temperature of 85° C. for five hours; and the largest loss was in experiment No. 112, in which lean beef round was put in cold water, which was heated slowly so that the temperature reached 85° C. at the end of one hour, and the cooking then continued for five hours more at this temperature. The data summarized also show that the greater part of the loss occurring in boiling meats was due to the removal of water, though there was also a considerable loss of nutrients, including proteids, nitrogenous and non-nitrogenous extractives, fat, and ash.

The amount of water removed during cooking varied from 39.25 to 59.74 per cent, and averaged 54.45 of the total in the uncooked meat. The smallest loss was noted in experiment No. 122, and the largest in experiment No. 112, which is in accordance with the statement in the paragraph above.

The total proteid recovered in the broth ranged from 0.93 to 7.87 per cent, averaging 3.18 per cent of the total amount present in the raw meat. The smallest loss of this constituent was found in experiment No. 153 in which a piece of lean beef round, cut about 5 inches thick and 4 inches across, was cooked for ten minutes in boiling water, and then at a temperature of 85° C. for three hours; and the greatest loss was in experiment No. 109, in which lean beef round, cut into 1-inch cubes, was cooked by putting it into cold water at first, then heating slowly so that the temperature reached 85° C. at the end of one hour, and finally cooking for three hours more at this temperature.

The proportion of fat originally present in the raw meat which was recovered in the broth varied from 3.52 to 36.35 per cent, averaging 17.50 per cent. The smallest loss was noted in experiment No. 144, in which a piece of lean beef round, cut about 5 inches thick and 4 inches across, was placed for ten minutes in boiling water, and then cooked at a temperature of 85° C. for three hours. The largest loss was observed in experiment No. 135, in which lean beef round in the form of cubes was browned in a small amount of fat and then cooked in water at about 100° C. for three hours.

The amount of nitrogenous organic extractives removed during the cooking varied from 50.19 to 95.25 per cent, averaging 71.81 per cent of the total amount originally present.

The proportion of the nonnitrogenous organic extractives recovered in the broth ranged from 49.23 to 94.15 per cent, the average being 72.13 per cent.

The mineral substances recovered in the broth varied from 45.50 to 74.54 per cent, the average being 62.55 per cent.

In a former bulletin[a] of this Office a summary of the results of 91 experiments with meat cooked in hot water made in this laboratory up to that time was given. The most important conclusions derived from these experiments were that (1) the total losses in weight when meat was cooked in hot water varied in individual tests from 10.61 to 50.20 per cent of the total weight of the fresh meat used, the average being 34.35 per cent. (2) The amount of water removed during cooking varied from 18.05 to 68.90 per cent and averaged 45.07 per cent of the total water in the uncooked meat. (3) The total protein removed in the broth varied from 3.25 to 12.67 per cent, averaging 7.25 per cent. (4) The proportion of fat originally present in the raw meat, which was recovered in the broth, varied from 0.60 to 37.40 per cent. (5) The mineral matter recovered in the broth varied from 20.04 to 67.39 per cent of the total in the uncooked meat, averaging 44.63 per cent. (6) The nutrients in the broth expressed in percentages of the total weight of the uncooked meat were on an average as follows: Water, 30.75; proteid, 1.41; fat, 1.21; and ash,

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 141.

0.46 per cent. (7) The fatter kinds and cuts of meat lost less water, protein, and mineral matter, but more fat than did the leaner kinds and cuts. (8) The losses increased in proportion to the extent of cooking; that is to say, other things being the same, the longer the time and the higher the temperature of cooking, the greater the losses resulting. (9) The different cuts of the same kind of meat behaved very differently as regards the amount and nature of the losses which they underwent when cooked in hot water. (10) The larger the piece of meat the smaller relatively the losses. (11) When meat is cooked in water at 80° to 85° C., placing the meat in hot or in cold water at the start had little effect on the amount of material found in the broth. (12) Beef which has been used for the preparation of beef tea or broth has lost comparatively little in nutritive value, though much of the flavoring material has been removed.

Comparing the average results obtained in the thirty-one experiments here reported with the average results obtained in previous work, it will be noted that the losses of water, fat, and ash in the former tests are considerably greater and the loss of proteid much less than in the latter. The greater losses of water, fat, and ash in the experiments reported in the present bulletin are undoubtedly due to the fact that, with two exceptions, all the meats used for cooking were cut into small cubes varying in size from 0.75 to 2 inches. In the ninety-one experiments previously reported most of the meats used were in solid pieces of considerable size, weighing as a rule from 2 to 6 pounds. The former experiments proved conclusively that the larger the piece of meat cooked by boiling the smaller the relative losses. The smaller apparent losses of proteid materials in the present experiments is due to the fact that a distinction has been made between proteid, nitrogenous extractives, and nonnitrogenous extractives, while in the former experiments these three different classes of substances were all classed under the general term protein.

The experiments summarized in Table 126 confirm the conclusions drawn from the earlier experiments, that the amount of material recovered in the broth when meat is cooked in hot water depends directly upon the length of time of cooking. The average losses in the fourteen cooking experiments in which the meats were cooked for three hours, were: 56.40 per cent water, 2.33 per cent proteid, 67.19 per cent nitrogenous extractives, 68.17 per cent nonnitrogenous extractives, 17.65 per cent fat, and 59.97 per cent ash. The average losses in the seventeen cooking experiments in which the meats were cooked for five hours were: 52.87 per cent water, 3.93 per cent proteid, 75.85 per cent nitrogenous extractives, 75.60 per cent nonnitrogenous extractives, 17.37 per cent fat, and 64.66 per cent ash.

It should also be mentioned in this connection that the average amount of fat in the meats cooked for three hours was only 6.49 per cent, while in the meats cooked for five hours it was 11.84 per cent.

Nothwang,[a] working in Rubner's laboratory, found that on cooking flesh in water at 100° C. from 57 to 60 parts of cooked meat were obtained from 100 parts of the flesh. Of this, 3 to 5 parts were made up of the solid matter suspended in the water in which the meat was boiled. In the broth he found some coagulated albumin and fat as a scum, gelatin, flesh bases (up to 50 per cent of the amount contained in the fresh meat), and four-fifths of the total salts of the meat.

The influence of the size of the piece of meat upon the resulting losses is strikingly shown in cooking experiments Nos. 144 and 153. In these two experiments the lean beef round was cut into pieces about 5 inches thick and 4 inches across, while the meat used in all the other boiling experiments here reported was in the form of small cubes. The losses resulting in experiments Nos. 144 and 153 were considerably less than those occurring in any of the other experiments. This would indicate the advantage of cutting the meat into small pieces in the preparation of soups and broths. On the other hand, the meat itself will be more juicy, better flavored, and of superior nutritive value if cooked in large pieces.

From the data here given it does not seem wise to draw final conclusions regarding the influence of the kind of meat, the fat content, and the different cuts of the same kind of meat upon the amount and nature of the losses sustained when cooked in hot water.

THE LOSSES INVOLVED IN THE ROASTING, BROILING, SAUTÉING, AND FRYING OF MEATS.

A summary of the results obtained in the experiments in which meats were cooked by dry heat is given in the following table, which includes the data concerning the kind of meat used, the time of cooking, and the apparent losses or gains of the different nutrients expressed as percentages of the total amounts of the corresponding nutrients in the uncooked meat and as percentages of the total quantity of meat cooked.

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[a] Arch. Hyg., 18 (1893), p. 80.

TABLE 127.—*Summary of the losses involved in the cooking of meats by roasting, broiling, sautéing, and frying.*

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Amount taken.	Fat in cooked meat.	Method of cooking.					
					Kind.	Total time.		Temperature at beginning.	Final cooking.	
									Temperature.	Time.
			Grams.	*Per. ct.*		*h.*	*m.*	*°C.*	*°C.*	*M.*
1770	146	Beef, round	966.87	9.66	Pot roast	3				
1781	155	do	1,011.33	9.87	do	3				
		Average	1,004.10	9.77						
1771	147	Beef, round	1,104.40	9.50	Roast	1		249	193	45
1782	156	do	1,110.88	5.42	do	1		249	193	45
		Average	1,107.64	7.46						
1660	120	Veal, leg	1,099.00	4.65	Roast	3				
		Average Nos. 1660, 1771, and 1782.	1,104.76	6.52						
1778	152	Beef, round	662.97	7.64	Gas broiled		10			
1766	142	do	673.91	8.18	Pan broiled		10			
1777	151	do	664.60	5.83	do		10			
		Average Nos. 1766 and 1777.	669.26	7.01						
1674	124	Beef, rump	571.12	47.59	Pan broiled		13			
1659	119	Veal, leg	572.72	5.20	do		15			
		Average Nos. 1659, 1674, 1766, and 1777.	620.59	16.65						
1765	141	Beef, round	670.51	9.88	Sautéed		10			
1776	150	do	641.09	6.34	do		10			
		Average	655.82	8.11						
1767	143	Beef, round	666.11	10.42	Fried		10	200	160	10
		Average of all beef samples.								
		Average of all veal samples.								
		Average of all beef and veal samples.								

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Loss or gain of each nutrient, expressed in percentages, of the weight of the uncooked meat.					
			Water.	Proteid.	Organic extractives.		Fat.	Ash.
					Nitrogenous.	Non-nitrogenous.		
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1770	146	Beef, round	−40.63	+1.51	−0.39	−0.78	−2.70	−0.38
1781	155	do	−44.87	− .11	− .54	− .77	+ .39	− .49
		Average	−42.75	+ .70	− .47	− .78	−1.16	− .44
1771	147	Beef, round	−16.03	− .07	− .05	− .44	− .23	− .09
1782	156	do	−15.53	+ .86	− .34	− .33	− .35	− .11
		Average	−15.78	+ .40	− .20	− .39	− .29	− .10
1660	210	Veal, leg	−22.41	+ .39	− .04	+ .10	− .38	− .04
		Average Nos. 1660, 1771, and 1782	−17.99	+ .39	− .14	− .22	− .32	− .08

Table 127.—*Summary of the losses involved in the cooking of meats by roasting, broiling, sautéing, and frying*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Loss or gain of each nutrient, expressed in percentages, of the weight of the uncooked meat.					
			Water.	Proteid.	Organic extractives.		Fat.	Ash.
					Nitrogenous.	Non-nitrogenous.		
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1778	152	Beef, round	−18.12	+0.29	+0.02	−0.05	+1.45	−0.08
1766	142	....do	−15.07	+ .69	+ .04	− .29	−1.31	− .07
1777	151	....do	−20.26	+1.29	+ .06	− .01	− .21	− .09
		Average Nos. 1766 and 1777	−17.67	+ .99	+ .05	− .15	− .76	− .08
1674	124	Beef, rump	−34.54	+ .19	+ .03	− .02	−1.80	+ .02
1659	119	Veal, leg	−29.98	+ .61	− .15	− .09	− .36	− .10
		Average Nos. 1659, 1674, 1766, and 1777	−24.96	+ .70	− .01	− .10	− .92	− .06
1765	141	Beef, round	−15.84	+1.05	− .01	− .30	+ .20	− .06
1776	150	....do	−16.11	+ .86	+ .05	− .02	+ .53	− .09
		Average	−15.98	+ .96	+ .02	− .16	+ .37	− .08
1767	143	Beef, round	−29.06	+1.55	− .03	− .44	− .78	− .05
		Average of all beef samples	−24.19	+ .74	− .11	− .32	− .64	− .14
		Average of all veal samples	−26.20	+ .50	− .10	+ .01	− .37	− .07
		Average of all beef and veal samples	−24.50	+ .70	− .10	− .27	− .43	− .13

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Loss or gain of nutrients, expressed in percentages, of total amounts in uncooked meat.					
			Water.	Proteid	Organic extractives.		Fat.	Ash.
					Nitrogenous.	Non-nitrogenous.		
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1770	146	Beef, round	−58.11	+8.39	−33.13	−44.95	−33.20	−35.61
1781	155	....do	−61.23	− .57	−47.83	−55.14	+ 7.84	−45.37
		Average	−59.67	+3.91	−40.48	−50.05	−12.68	−40.49
1771	147	Beef, round	−22.92	− .41	− 3.91	−25.33	− 2.80	− 8.03
1782	156	....do	−21.19	+4.60	−29.96	−23.60	− 7.04	−10.40
		Average	−22.06	+2.10	−16.94	−24.17	− 4.92	− 9.22
1660	120	Veal, leg	−29.66	+2.18	− 3.54	+ 7.17	− 9.42	− 3.89
		Average Nos. 1660, 1771, and 1782	−24.59	+2.12	−12.47	−13.92	− 6.42	− 7.44
1778	152	Beef, round	−24.72	+1.58	+ 1.74	− 3.66	+29.55	− 6.92
1766	142	....do	−21.56	+3.85	+ 3.52	−16.90	−16.10	− 6.16
1777	151	....do	−27.64	+6.88	+ 5.59	− .86	− 4.23	− 8.15
		Average Nos. 1766 and 1777	−24.60	+5.37	+ 4.56	− 8.88	−10.17	− 7.16
1674	124	Beef, rump	−66.10	+1.37	+ 4.51	− 2.58	− 5.57	+ 2.84
1659	119	Veal, leg	−39.69	+3.36	−14.22	−6.37	− 9.10	− 8.73
		Average Nos. 1659, 1674, 1766, and 1777	−38.75	+3.87	− .15	− 6.68	− 8.75	−5.05
1765	141	Beef, round	−22.64	+5.87	− 1.14	−17.50	+ 2.40	− 6.05
1776	150	....do	−21.98	+4.60	+ 4.01	− 1.45	+10.74	− 8.01
		Average	−22.31	+5.24	+ 1.44	− 9.48	+ 6.57	− 7.03

TABLE 127.—*Summary of the losses involved in the cooking of meats by roasting, broiling, sautéing, and frying*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Loss or gain of nutrients, expressed in percentages, of total amounts in uncooked meat.					
			Water.	Proteid.	Organic extractives.		Fat.	Ash.
					Nitrogenous.	Nonnitrogenous.		
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
1767	143	Beef, round	−41.56	+8.61	− 2.93	−25.17	− 9.58	− 1.53
		Average of all beef samples	−35.42	+1.07	− 9.05	−19.74	− 6.43	−12.66
		Average of all veal samples	−31.68	+2.77	− 8.88	+ .10	− 9.26	− 6.31
		Average of all beef and veal samples	−35.31	+3.87	− 9.02	−16.64	− 6.87	−11.68

Examination of this table shows that in the case of two pot roasts the average losses expressed as percentages of the several nutrients originally present were: 59.67 per cent water, 40.48 per cent nitrogenous extractives, 50.05 per cent nonnitrogenous extractives, 12.68 per cent fat, and 40.49 per cent ash. There was an apparent gain of 3.91 per cent of proteid.

The average losses in the three roasting experiments were: 24.59 per cent water, 12.47 per cent nitrogenous extractives, 13.92 per cent nonnitrogenous extractives, 6.42 per cent fat, and 7.44 per cent ash. Here again there was an apparent gain in the amount of proteid which amounted to 2.12 per cent.

The losses occurring in the single test in which meat was broiled over a gas flame were as follows: 24.72 per cent water, 3.66 per cent nonnitrogenous extractives, and 6.92 per cent ash. In this experiment there was an apparent gain in the proteid, nitrogenous extractives, and fat amounting to, respectively, 1.58, 1.74, and 29.55 per cent of the total quantity of each of these nutrients in the uncooked meat.

In the four pan-broiling experiments the average losses were: 38.75 per cent water, 0.15 per cent nitrogenous extractives, 6.68 per cent nonnitrogenous extractives, 8.75 per cent fat, and 5.05 per cent ash. There was an apparent gain of 3.87 per cent proteid.

In the two experiments in which the meat was sautéed the average losses were: 22.31 per cent water, 9.48 per cent nonnitrogenous extractives, and 7.03 per cent ash. Again there was an apparent gain of proteid amounting to 5.24 per cent, and also an apparent gain of nitrogenous extractives and fat amounting to 1.44 and 6.57 per cent, respectively.

In the single experiment in which the meat was fried the average losses were: 41.56 per cent water, 2.93 per cent nitrogenous extractives, 25.17 per cent nonnitrogenous extractives, 9.58 per cent fat, and 4.53 per cent ash. There was an apparent gain of 8.64 per cent proteid.

It is evident from the figures under discussion that a considerable loss in weight results from each of these methods of cooking meats. This is due chiefly to the evaporation of water, but there are also in all instances small losses of total food nutrients. Judging from the limited data here available the losses resulting when meat is cooked as a pot roast are much greater than those which occur in roasting, gas broiling, pan broiling, sautéing, and frying, and the losses which take place when meats are cooked by roasting are apparently greater than those in broiling, sautéing, and frying. The losses noted in connection with the roasting, pan broiling, and sautéing experiments agree in general with those obtained in previous experiments[a] in which meats were cooked by these methods.

In all the roasting, broiling, sautéing, and frying experiments here reported there was an apparent gain of proteid matter during the cooking, and in a few cases there was apparently a small gain of the nitrogenous extractives and also of fat, even where the latter had not been added either before or during the cooking. It is plainly evident that cooking according to these methods could not add nutritive material to the meat except where fat was added in the pot roasting, sautéing, and frying experiments. With the knowledge at present available concerning the nature of the changes resulting in cooking, it is not easy to account for this apparent gain of fat and nitrogenous substances which occurs during the cooking of meats by those methods. This question is being further studied in connection with these investigations.

Attention should be called to the comparatively small losses which take place when meats are cooked by dry heat compared with those which occur when the cooking is done in hot water. The average losses resulting in the 13 experiments in which the meats were cooked by dry heat, expressed in percentages of the total amount of each constituent in the meat, were as follows: 35.31 per cent water, 9.02 per cent nitrogenous extractives, 16.64 per cent nonnitrogenous extractives, 6.87 per cent fat, and 11.68 per cent ash. There was apparently an average gain of 3.87 per cent of proteid.

The average losses occurring in the 31 experiments in which the meat was cooked in hot water, expressed in percentages of the total amount of each constituent of the meat, were as follows: 54.45 per cent water, 3.18 per cent proteid, 71.81 per cent nitrogenous extractives, 72.13 per cent nonnitrogenous extractives, 17.50 per cent fat, and 62.55 per cent ash. It is thus evident that the losses of nutritive constituents which occur in cooking meats in hot water are several times greater than those resulting when meats are cooked by dry heat.

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 141.

These differences between the losses occurring when meats are cooked with and without contact with hot water are also plainly noticeable when the results are calculated to the basis of the weight of the uncooked meats. The average losses resulting in the 13 experiments in which the meats were cooked by dry heat thus expressed were: 24.50 per cent water, 0.10 per cent nitrogenous extractives, 0.27 per cent nonnitrogenous extractives, 0.43 per cent fat, and 0.13 per cent ash. The apparent gain of proteid was 0.70 per cent.

The average losses resulting in the 31 boiling experiments, expressed in percentages of the weight of the uncooked meats, were 39.09 per cent water, 0.63 per cent proteid, 0.83 per cent nitrogenous extractives, 1.07 per cent nonnitrogenous extractives, 1.26 per cent fat, and 0.61 per cent ash.

These conclusions are in accord with those on page 140, drawn from the composition of the cold-water extracts of meat cooked in different ways, that cooking meat by dry heat retains more of the nutritive material than cooking it in hot water.

A STUDY OF MEAT BROTHS AND SOUPS.

In connection with the nutrition investigations upon meats carried on under the direction of this Office[a] a large amount of unpublished data upon the chemical composition and nutritive value of meats, broths, and soups has been accumulated. Since the available data regarding the composition and true nutritive value of meat broths and soups are as yet quite meager, it has been thought best to present this material in connection with this bulletin. Past investigations have shown in a general way that meat broths and soups contain as a rule only small quantities of true nutritive material, consisting of a portion of the nitrogenous and nonnitrogenous organic extractives (meat bases), proteids, fats, and mineral substances of the meat from which they have been prepared. The true nutritive value of broths is still a disputed question, because a considerable proportion of their solid constituents are composed of the so-called extractives, such as creatin, creatinin, organic acids, glycogen, inosite, and unidentified organic substances and inorganic salts, and the action of these materials upon the animal body is not yet well understood. It seems probable, however, that these extractives have little true nutritive value and that they act chiefly as stimulants to the body or to the process of digestion.

The extended investigations of Pawlow[b] and his associates show that the importance of meat extractives as stimulants to the secretion of normal gastric juice can hardly be overestimated. These bodies were found to be much more active gastric stimulants than sugar with water or any of the other foods or food accessories tested. It seems apparent, further, that the stimulation of the flow of gastric juice by the specific character of the food eaten is a normal and important part of digestion.

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[a] U. S. Dept. Agr., Office of Experiment Stations Buls. 102 and 141

[b] The Work of the Digestive Glands. London, 1902.

If Pawlow's views are correct, and they are supported by a very large amount of experimental work of a high order, they furnish an explanation of the belief long held by many that soup and broth have a value in dietetics out of proportion to the nutritive material they supply, and, indeed, they offer an explanation of the value of savory foods in general.

In connection with the work here reported it is interesting to summarize the more important investigations of the composition of soup and broth which have been found. For the purpose of studying the composition of broth, König[a] and associates prepared a meat broth from 500 grams of beef and 189 grams of veal bones by the ordinary household method. They obtained 543 cubic centimeters of strong broth or soup, which upon analysis gave the following results: Water, 95.18; total dry substance, 4.82; proteid, 1.19; fat, 1.48; extractives,. 1.83, and total nitrogen 0.19 per cent. A. Payen[b] prepared three soups from meat and bones, using as flavoring materials salt, vegetables, and spices. These broths were analyzed with the following average results: Water, 97.73; total dry residue, 1.26; organic matter, 1.31, and salt, 0.96 per cent.

Mrs. Ellen H. Richards and Mrs. Mary H. Abel[c] in 1889 and 1900 prepared and studied the composition of various kinds of broths. The following table gives the results of their analyses:

TABLE 128.—*Composition of broths, beef tea, etc.*

Kind.	Meat.	Total solids.	Solids, juice filtered before coagulation.	Solids, juice filtered after coagulation.	Coagulable albumin.	Extract of meat.	Salts or ash.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Beef juice from meat slightly broiled and pressed (round)	26.8	11.9	10.8	4.93	6.97	3.90	....
Beef juice from meat slightly broiled and pressed (neck)	21.9	9.9	9.4	4.72	5.18	3.56	1.36
Beef tea, chopped beef heated in bottle without water	26.4	7.91	....	5.72	2.19	2.09	....
Beef tea, New England Hospital, with water	....	3.23	....	2.55	.68	....	....
Beef tea, with equal weight of water two hours at 70° C., then boiled two hours	....	....	....	....	....	2.15	....
Beef tea, with twice its weight of water two hours at 70° C., then two hours at 85° C	....	....	....	....	....	2.62	....
Beef broth, New England kitchen, average of 26 analyses	....	3.53	....	....	....	4.40	....

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[a] Chemie der Menschlichen Nahrungs- und Genussmittel. 4. ed., II, p. 1445.

[b] Substances Alimentaires, 1865, p. 97.

[c] U. S. Dept. Agr., Office of Experiment Stations Bul. 21, p. 92.

From the work above mentioned it is apparent that the amount of solids in meat broths is generally very small. The analyses of meat broths made by us confirm this conclusion. The following tables summarize the results of the analyses of the broths made in connection with these nutrition investigations since 1898. Table 129 gives the weight of each nutrient actually found by analysis in the clear filtered broths and in the suspended matter in the original broth.

TABLE 129.—*Composition of the clear, filtered broths and the solid matter in the broths.*

Broth from meat, laboratory No.	Experiment No.	Weight of uncooked meat.	Total nutrients in clear broth.						Total nutrients in suspended matter in broth.			
			Proteid.	Organic extractives.			Ash.	Total nutrients.	Proteid.	Fat.	Ash.	Total nutrients.
				Nitrogenous.	Non-nitrogenous.	Total.						
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Gm.*	*Grams.*
892...	16	1,220.3	1.273	6.500	7.933	14.493	5.464	21.230	1.111	9.533	....	10.644
893...	16	1,477.8	2.436	7.375	9.405	16.780	6.140	25.356	1.576	12.623	....	14.199
771a..	17	705.5	.370	5.505	7.411	12.916	4.044	17.330	1.757	5.586	....	7.343
771b..	17	660.8	.605	5.010	7.050	12.060	3.875	16.540	1.936	7.606	....	9.542
894...	18	433.2	.542	3.869	5.088	8.957	3.170	12.669	.382	.958	....	1.340
895...	18	2,080.6	2.473	15.305	21.025	36.330	12.326	51.129	1.713	2.979	....	4.692
1027..	19	2,141.3	2.780	18.364	16.056	34.420	11.620	48.820	1.350	10.190	....	11.540
1097..	19	1,139.5	1.460	7.960	9.600	17.560	5.430	24.450	1.000	2.880	....	3.880
777a..	20	825.8	2.268	5.568	7.536	13.104	5.016	20.388	.509	6.810	....	7.319
777b..	20	739.5	2.604	5.624	7.068	12.692	4.576	19.872	.387	6.722	....	7.109
779a..	21	750.0	2.964	5.480	6.864	12.344	4.832	20.140	.441	8.147	....	8.588
779b..	21	660.5	2.824	5.256	6.832	12.088	4.432	19.344	.495	4.668	....	5.163
781a..	22	657.0	2.176	4.416	6.714	11.130	4.010	17.316	.422	5.734	....	6.156
781b..	22	755.8	2.224	5.652	7.448	13.100	4.760	20.084	.466	3.344	....	3.810
809a..	23	742.8	1.072	5.376	7.392	12.768	4.576	18.416	.334	8.134	....	8.468
809b..	23	686.6	.812	5.452	7.612	13.064	4.460	18.336	.277	5.082	....	5.359
820a..	24	915.1	2.203	4.005	5.507	9.512	3.365	15.080	4.419	1.333	....	5.752
820b..	24	837.3	3.385	4.750	6.955	11.705	3.920	19.010	5.243	1.652	....	6.895
823a..	25	798.1	.890	6.215	7.890	14.105	4.605	19.600	2.021	.975	....	2.996
823b..	25	944.5	1.390	6.940	9.055	15.995	5.185	22.570	1.832	4.846	....	6.678
1091..	26	1,383.1	1.440	8.246	10.894	19.140	6.320	26.900	.570	11.740	....	12.310
1092..	26	1,409.6	1.930	7.037	9.153	16.190	5.380	23.500	.440	9.530	....	9.970
1093..	27	2,120.1	1.680	5.189	7.301	12.490	4.290	18.460	1.670	17.860	....	19.530
1094..	27	2,193.9	1.090	3.915	7.415	11.330	3.390	15.810	.910	25.910	....	26.820
1095..	28	1,211.8	1.470	8.913	12.717	21.630	7.460	30.560	.970	20.370	....	21.340
1096..	28	1,152.6	1.890	8.429	11.561	19.990	6.630	28.510	.590	20.190	....	20.780
1098..	29	1,017.1	1.990	6.268	10.032	16.300	4.990	23.280	.330	31.710	....	32.040
1099..	29	1,740.5	2.790	8.766	13.324	22.090	6.830	31.710	2.170	30.750	....	32.920
1146..	30	713.6	.875	4.910	6.575	11.485	3.623	15.983	.185	4.312	....	4.497
1147..	30	2,323.1	2.085	12.745	16.905	29.650	10.171	41.906	.652	8.854	....	9.506
1158..	31	1,380.2	1.060	6.408	9.799	16.207	4.818	22.085	.690	2.579	....	3.269
1159..	31	1,435.9	....	....	....	....	9.153	41.150	1.342	14.152	....	15.494
1160..	32	1,715.9	1.144	3.864	6.009	9.873	2.997	14.014	1.066	89.812	....	90.878
1161..	32	1,825.8	1.217	5.212	8.095	13.307	3.998	18.522	.615	154.161	....	154.776
1162..	33	2,393.2	2.470	6.487	9.091	15.578	4.637	22.685	1.178	19.760	....	20.938
1163..	33	2,729.8	2.825	5.943	8.465	14.408	4.390	21.623	.552	8.471	....	9.023
1169..	34	1,806.4	2.090	6.374	8.516	14.890	4.490	21.470	.770	51.970	....	52.740
1170..	34	1,923.6	2.190	5.815	7.295	13.110	4.010	19.310	.450	55.700	....	56.150
1171..	35	1,523.7	1.260	6.272	8.378	14.650	5.230	21.140	1.290	7.060	....	8.350
1172..	35	1,765.0	1.220	6.535	9.385	15.920	5.210	22.350	.590	14.750	....	15.340
1173..	36	1,838.5	1.950	5.058	7.232	12.290	4.000	18.240	.730	8.490	....	9.220
1174..	36	1,608.5	.980	5.288	7.732	13.020	3.830	17.830	.650	72.810	....	73.460
1175..	37	1,882.7	.850	6.195	8.045	14.240	4.880	19.970	.210	26.770	....	26.980
1176..	37	2,016.7	.960	6.914	9.206	16.120	5.550	22.630	.510	38.420	....	38.930
1177..	38	1,774.2	6.193	7.966	11.191	19.157	6.053	31.403	1.107	13.832	....	14.939
1178..	38	2,334.7	7.583	9.102	11.652	20.754	7.008	35.345	1.351	2.908	....	4.259
1179..	39	964.7	1.424	5.923	7.463	13.386	4.045	18.855	.658	79.584	....	80.242
1180..	39	1,284.2	2.489	7.044	9.982	17.026	4.805	24.320	1.205	68.266	....	69.471
1181..	40	1,648.3	5.710	7.949	13.291	21.240	6.310	33.260	.910	2.390	....	3.300
1182..	40	1,939.1	6.670	7.096	10.914	18.010	5.890	30.560	1.500	1.170	....	2.670
1183..	41	912.8	1.030	4.051	7.949	12.000	3.520	16.540	.300	41.100	....	41.400
1184..	41	1,268.1	1.750	4.715	9.525	14.240	4.230	20.220	.680	88.140	....	88.820
1205..	48	1,237.9	.970	6.938	9.159	16.097	5.550	22.610	.650	.750	....	1.400
1206..	48	1,210.2	1.090	9.595	12.496	22.091	7.210	30.400	.480	.630	....	1.110
1211..	51	2,141.1	3.090	10.811	12.874	23.685	8.590	35.370	.750	.650	....	1.400
1212..	51	1,529.9	2.510	10.284	12.586	22.870	8.440	33.820	1.150	4.860	....	6.010
1242..	54	2,108.6	2.250	8.658	9.902	18.560	7.210	28.020	1.480	1.500	....	2.980
1243..	54	1,128.0	1.700	6.757	7.380	14.137	5.330	21.170	.840	2.690	....	3.530
1368..	59	500.0	1.080	4.178	4.905	9.083	3.070	13.240	1.520	.780	....	2.300
1369..	60	2,500.0	7.670	16.783	17.204	33.987	12.340	53.990	14.430	3.990	....	18.420

TABLE 129.—*Composition of the clear filtered broths and the solid matter in the broths*—Continued.

Broth from meat laboratory No	Experiment No	Weight of uncooked meat	Total nutrients in clear broth.						Total nutrients in suspended matter in broth.			
			Proteid.	Organic extractives.			Ash.	Total nutrients.	Proteid.	Fat.	Ash.	Total nutrients.
				Nitrogenous.	Non-nitrogenous.	Total.						
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Gram.*	*Grams.*
1370..	61	500.0	0.990	4.115	5.225	9.340	3.350	13.680	1.720	6.300	....	8.030
1371..	62	2,500.0	2.580	20.677	24.589	45.266	15.380	63.220	10.600	33.130	....	43.730
1376..	63	520.8	2.570	2.906	3.336	6.242	2.860	11.670	1.330	.260	....	1.590
1377..	64	2,384.5	7.800	11.801	13.819	25.620	9.480	42.900	6.690	3.050	....	9.740
1378..	65	501.4	.470	3.818	4.104	7.922	3.230	11.620	.210	5.520	....	5.730
1379..	66	2,502.6	2.720	15.799	20.305	36.104	10.470	49.300	3.960	15.700	....	19.660
1380..	67	500.0	.890	2.317	1.179	3.496	3.270	7.650	5.110	.970	....	6.080
1381..	68	2,500.0	9.380	17.638	20.542	38.180	11.800	59.360	11.010	3.660	....	14.670
1382..	69	500.0	.300	4.718	5.531	10.249	3.210	13.760	.460	4.010	....	4.470
1383..	70	2,500.0	1.440	21.938	26.290	48.228	15.350	64.920	17.100	22.170	....	39.280
1384..	71	500.0	2.230	3.439	4.039	7.478	2.430	12.140	2.490	.430	....	2.920
1385..	72	2,500.0	4.890	10.447	11.670	22.117	7.820	34.830	11.190	4.970	....	16.170
1386..	73	500.0	.290	3.990	4.851	8.841	3.350	12.490	1.780	3.030	....	4.810
1387..	74	2,500.0	3.160	14.466	10.305	24.771	9.150	37.090	8.660	4.600	....	13.260
1639..	107	1,000.0	3.418	8.877	12.501	21.378	6.660	31.455	1.728	7.418	....	9.146
1641..	108	1,000.0	2.184	10.633	13.590	24.223	7.526	33.933	4.240	6.087	0.040	10.367
1642..	109	1,000.0	1.726	10.214	13.385	23.599	7.725	33.050	13.844	5.935	.008	19.786
1643..	110	1,000.0	4.063	8.759	10.916	19.675	6.375	30.113	2.121	8.476	....	10.597
1644..	111	1,000.0	2.201	9.162	11.954	21.116	6.994	30.311	3.437	8.501	....	11.938
1645..	112	1,000.0	1.476	9.903	12.667	22.570	7.235	31.280	6.529	11.421	....	17.949
1646..	113	1,000.0	2.318	9.177	11.944	21.121	7.381	30.819	6.744	7.000	....	13.744
1652..	114	1,000.0	5.440	6.683	9.582	16.265	5.080	26.785	1.372	.683	.013	2.068
1653..	115	1,000.0	2.740	8.465	11.305	19.770	6.240	28.750	2.359	.572	....	2.930
1654..	116	1,000.0	4.046	7.564	11.366	18.930	6.220	29.195	6.077	1.883	.017	7.977
1658..	118	1,000.0	4.528	7.911	9.597	17.508	6.320	28.355	5.694	4.975	.009	10.678
1664..	117	1,000.0	5.001	7.774	9.124	16.898	6.150	28.050	1.356	3.306	.009	4.671
1665..	121	700.0	....	....	....	....	4.670	20.255	....	7.115	.024	8.539
1669..	122	1,000.0	6.115	5.611	7.384	12.995	4.355	23.465	.890	64.807	.018	65.715
1673..	123	1,000.0	3.220	6.046	8.549	14.595	4.965	22.780	1.840	63.196	.005	65.041
1703..	125	1,000.0	3.381	8.629	10.274	18.903	5.932	28.216	1.072	23.585	.007	24.663
1704..	126	1,000.0	8.749	7.447	9.400	16.847	5.260	30.856	1.363	30.870	.016	32.250
1707..	127	1,000.0	14.344	1.396	6.612	8.008	1.200	23.552	.270	20.161	....	20.430
1708..	128	1,000.0	5.596	1.211	3.828	5.039	1.336	11.971	.245	13.436	....	13.681
1709..	129	1,000.0	.883	.830	1.480	2.310	.564	3.756	.367	75.625	.005	75.997
1710..	130	1,000.0	2.266	1.297	1.692	2.989	1.064	6.320	.219	126.563	.019	126.801
1720..	131	1,000.0	2.873	9.486	13.361	22.847	6.368	32.088	1.369	12.641	.021	14.031
1721..	132	1,000.0	6.014	8.807	12.740	21.547	5.896	33.456	1.038	11.348	.011	12.396
1743..	133	1,000.0	3.500	8.871	11.099	19.970	6.200	29.670	.443	4.565	.016	5.024
1744..	134	1,000.0	2.766	8.678	11.856	20.534	6.120	29.420	.554	3.127	.018	3.699
1745..	135	1,000.0	3.309	8.195	10.656	18.851	5.670	27.830	.980	24.789	.027	25.796
1746..	136	1,000.0	2.130	8.351	10.949	19.300	6.030	27.460	1.324	16.180	.022	17.526
1754..	137	900.0	1.559	7.753	9.506	17.259	5.340	24.159	3.312	7.771	.037	11.120
1755..	138	900.0	2.336	8.007	9.557	17.564	5.680	25.580	2.826	14.536	.020	17.381
1756..	139	900.0	1.536	7.836	9.528	17.364	5.490	24.390	1.334	5.255	.030	6.618
1757..	140	900.0	2.211	8.029	9.749	17.778	5.700	25.689	1.127	5.839	.022	6.988
1772..	145	1,074.8	1.785	8.067	8.957	17.024	5.570	24.380	.852	4.696	.017	5.565
1773..	144	1,027.7	1.497	6.909	7.544	14.453	4.740	20.690	.572	1.752	.012	2.337
1783..	154	1,052.2	1.321	7.702	9.422	17.124	5.520	23.965	1.299	....	.015	....
1784..	153	1,098.3	1.777	8.067	9.596	17.663	5.670	25.110	.258	4.182	.003	4.437

COMPOSITION OF COMPLETE MEAT BROTHS.

Table 130 for the experiments of 1898–1903, and Table 131 for 1903–4 give the composition of the original complete broths. Since the broths varied in consistency, it was necessary to reduce them to a common basis before they could be accurately compared. Each broth was therefore diluted with water until it reached the density at which the amount made from 100 grams of the original meat would weigh 100 grams; or, what is the same thing, the point at which the broth made from 1 pound of meat would measure 1.04 pints. The kind and cut of meat and the method of cooking are indicated in the tables, which hardly need further explanation.

TABLE 130.—*Composition of original complete broth.* (*Results of experiments made in 1898–1903.*)

[Calculated to the basis, 100 grams of meat give 100 grams of broth, or 1 pound of meat gives 1.01 pints of broth.]

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Amount taken.	Fat in cooked meat.	Method of cooking.		
					Temperature.		Duration of cooking.
					At beginning.	During cooking.	
			Grams.	*Per cent.*	°*C.*	°*C.*	*Hours.*
1158	31	Beef, round, lean	1,380.20	7.10	100	80–85	1½
1095	28	do	1,211.75	7.27	100	100	2
1096	28	do	1,152.63	7.95	100	100	2
		Average Nos. 1095 and 1096	1,182.19	7.61			
1370	61	Beef, round, lean, ½-inch cubes	500.00	14.49	100	80–85	2
1382	69	do	500.00	12.39	100	80–85	2
		Average	500.00	13.44			
1371	62	Beef, round, lean, ½-inch cubes	2,500.00	12.70	100	80–85	2
1383	70	do	2,500.00	10.75	100	80–85	2
		Average	2,500.00	11.73			
		Average Nos. 1370, 1371, 1382, and 1383					
894	18	Beef, round, lean, small piece	433.20	2.70	100	80–85	2
779b	21	do	660.50	5.87	100	80–85	2
809b	23	do	686.00	6.34	100	80–85	2
781b	22	do	755.00	6.50	100	80–85	2
		Average	633.68	5.35			
1378	65	Beef, round, lean, small piece	501.41	7.90	100	80–85	2
779a	21	do	750.00	8.98	100	80–85	2
1386	73	do	500.00	8.99	100	80–85	2
809a	23	do	742.80	9.40	100	80–85	2
781a	22	do	657.00	10.31	100	80–85	2
777a	20	do	825.80	10.52	100	80–85	2
777b	20	do	739.50	11.51	100	80–85	2
		Average	673.79	9.66			
		Average Nos. 777a, 777b, 779a, 779b, 781a, 781b, 809a, 809b, 894, 1378, and 1386	659.20	8.09			
1211	51	Beef, round, lean, large piece	2,141.09	1.78	100	80–85	2
1205	48	do	1,237.90	1.97	100	80–85	2
1242	54	do	2,108.62	3.45	100	80–85	2
895	18	do	2,080.00	3.64	100	80–85	2
		Average	1,891.90	2.71			
1379	66	Beef, round, lean, large piece	2,500.00	8.56	100	80–85	2
1027	19	do	2,141.25	8.38	100	80–85	2
1387	74	do	2,500.00	9.23	100	80–85	2
1097	19	do	1,139.48	10.53	100	80–85	2
		Average	2,070.18	9.18			
		Average Nos. 895, 1027, 1097, 1205, 1211, 1242, 1379, and 1387	1,984.04	5.95			
892	16	Beef, round, fat	1,220.30	19.99	100	80–85	2
893	16	do	1,477.80	18.88	100	80–85	2
1091	26	do	1,383.07	12.84	100	80–85	2
1092	26	do	1,409.64	12.67	100	80–85	2
1172	35	do	1,764.97	15.45	100	80–85	2
		Average	1,451.16	15.96			
1093	27	Beef, "plate boil," very fat	2,120.13	32.32	100	80–85	2
1094	27	do	2,193.89	35.49	100	80–85	2
		Average	2,157.01	33.90			
1098	29	Beef, round, rather fat	1,017.05	12.54	100	80–85	3
1099	29	do	1,740.51	18.18	100	80–85	3
1146	30	do	713.60	7.74	100	80–85	3
1147	30	do	2,323.10	10.00	100	80–85	3
		Average	1,448.56	12.12			

TABLE 130.—*Composition of original complete broth. (Results of experiments made in 1898–1903)*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Amount taken.	Fat in cooked meat.	Method of cooking. Temperature. At beginning.	Method of cooking. Temperature. During cooking.	Method of cooking. Duration of cooking.
			Grams.	*Per cent.*	*°C.*	*°C.*	*Hours.*
1160	32	Beef, "plate boil," very fat	1,715.90	50.14	100	80–85	3
1161	32	....do	1,825.80	50.73	100	80–85	3
1162	33	Beef, neck, very fat	2,393.20	23.62	100	80–85	3
1163	33	....do	2,729.80	29.87	100	80–85	3
1169	34	Beef, ribs, very fat	1,806.37	26.04	100	80–85	3
1170	34	....do	1,923.58	34.06	100	80–85	3
		Average of above	2,065.77	35.74	....	....	....
1177	38	Veal, leg	1,774.20	7.79	100	80–85	3
1178	38	....do	2,334.70	4.18	100	80–85	3
1181	40	....do	1,648.31	5.11	100	80–85	3
1182	40	....do	1,949.09	4.33	100	80–85	3
		Average	1,926.58	5.35	....	....	....
1179	39	Mutton, leg	964.70	25.50	100	80–85	3
1180	39	....do	1,284.20	18.57	100	80–85	3
1183	41	....do	912.82	14.35	100	80–85	3
1184	41	....do	1,268.14	20.69	100	80–85	3
		Average	1,107.46	19.78	....	....	....
1173	36	Pork, fresh ham	1,838.40	32.83	100	80–85	3
1174	36	....do	1,608.50	44.66	100	80–85	3
1175	37	....do	1,882.66	36.82	100	80–85	3
1176	37	....do	2,016.70	40.64	100	80–85	3
		Average	1,836.56	38.74	....	....	....
1159	31	Beef, round, lean	1,435.90	11.18	100	80–85	5
1206	48	....do	1,210.15	1.65	100	80–85	5
1212	51	....do	1,529.94	3.80	100	80–85	5
1243	54	....do	1,128.00	3.69	100	80–85	5
		Average	1,326.00	5.08	....	....	....
820a	24	Beef, round, lean	915.10	6.11	20–25	50	6
820b	24	....do	837.30	6.58	20–25	50	6
		Average	876.20	6.35	....	....	....
1376	63	Beef, round, lean, one piece	520.77	2.88	20–25	47–50	5
1384	71	....do	500.00	5.56	20–25	47–50	5
		Average	510.38	4.22	....	....	....
1377	64	Beef, round, lean, one piece	2,384.54	8.91	20–25	47–50	5
1385	72	....do	2,500.00	11.46	20–25	47–50	5
		Average	2,442.27	10.18	....	....	....
1368	59	Beef, round, ½-inch cubes	500.00	9.33	20–25	47–50	5
1380	67	....do	500.00	9.50	20–25	47–50	5
		Average	500.00	9.42	....	....	....
1369	60	Beef, round, ½-inch cubes	2,500.00	10.62	20–25	47–50	5
1381	68	....do	2,500.00	8.98	20–25	47–50	5
		Average	2,500.00	9.80	....	....	....
		Average Nos. 1368, 1369, 1376, 1377, 1380, 1381, 1384, and 1385	....	8.41	....	....	....
1171	35	Beef, round, lean	1,523.68	12.92	20–25	57–60	5
771a	17	....do	705.50	7.23	20–25	80	2¾
771b	17	....do	660.80	8.50	20–25	80	2¾
823a	25	....do	798.10	6.13	20–25	80	2¾
823b	25	....do	944.50	3.47	20–25	80	2¾
		Average Nos. 771a, 771b, 823a, and 823b	777.22	6.33	....	....	....
		Average of 72 samples	1,426.55	....	....	....	....
		Maximum	2,729.80	....	....	....	....
		Minimum	500.00	....	....	....	....

NOTE.—Experiment No. 31 not included in average.

TABLE 130.—*Composition of original complete broth. (Results of experiments made in 1898–1903)*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Percentage composition of original complete broth.										
						Organic extractives.					Nitrogen.		
			Water.	Total solid matter.	Proteid.	Nitrogenous.	Nonnitrogenous.	Total.	Fat.	Ash.	Proteid.	Nonproteid.	Total.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1158	31	Beef, round, lean	98.16	1.84	0.13	0.47	0.69	1.16	0.20	0.35	0.021	0.151	0.172
1095	28	do	95.72	4.28	.20	.73	1.05	1.78	1.68	.62	.032	.234	.266
1096	28	do	95.72	4.28	22	.73	1.00	1.73	1.75	.58	.035	.234	.269
		Average Nos. 1095 and 1096	95.72	4.28	.21	.73	1.03	1.76	1.71	.60	.034	.234	.268
1370	61	Beef, round, lean, ½-inch cubes	95.66	4.34	.54	.82	1.05	1.87	1.26	.67	.086	.263	.349
1382	69	do	96.36	3.64	.15	.94	1.11	2.05	.80	.64	.024	.301	.325
		Average	96.01	3.99	.35	.88	1.08	1.96	1.03	.66	.055	.282	.337
1371	62	Beef, round lean, ½-inch cubes	95.72	4.28	.53	.83	.98	1.81	1.33	.61	.085	.266	.351
1383	70	do	95.83	4.17	.74	.88	1.05	1.93	.89	.61	.118	.282	.400
		Average	95.78	4.23	.64	.86	1.02	1.87	1.11	.61	.102	.274	.376
		Average Nos. 1370, 1371, 1382, and 1383	95.89	4.11	.49	.87	1.05	1.91	1.07	.63	.078	.278	.356
894	18	Beef, round, lean, small piece	96.77	3.23	.21	.89	1.17	2.06	.22	.74	.034	.285	.319
779b	21	do	96.29	3.71	.50	.80	1.03	1.83	.71	.67	.080	.256	.336
809b	23	do	96.55	3.45	.16	.79	1.11	1.90	.74	.65	.026	.253	.279
781b	22	do	96.84	3.16	.36	.75	.98	1.73	.11	.63	.058	.240	.298
		Average	96.61	3.39	.31	.81	1.07	1.88	.53	.67	.049	.259	.308
1378	65	Beef, round, lean, small piece	96.54	3.46	.14	.76	.82	1.58	1.10	64	.022	.243	.265
779a	21	do	96.17	3.83	.45	.73	.92	1.65	1.09	.61	.072	.234	.306
1386	73	do	96.54	3.46	.11	.80	.97	1.77	.61	.67	.066	.256	.322
809a	23	do	96.38	3.62	.19	.72	1.00	1.72	1.09	.62	.030	.231	.261
781a	22	do	96.43	3.57	.40	.67	1.02	1.69	.87	.61	.064	.214	.278
777a	20	do	96.65	3.35	.34	.67	.91	1.58	.82	.61	.054	.214	.268
777b	20	do	96.35	3.65	40	.76	.96	1.72	.91	.62	.064	.243	.307
		Average	96.44	3.56	.33	.76	.94	1.67	.93	.63	.053	.234	.287
		Average Nos. 777a, 777b, 779a, 779b, 781a, 781b, 809a, 809b, 894, 1378, and 1386	96.49	3.50	.32	.76	.99	1.75	.78	.65	.052	.243	.294
1211	51	Beef, round, lean, large piece	98.28	1.72	.18	.51	.60	1.11	.03	.40	.029	.163	.192
1205	48	do	98.06	1.94	.13	.56	.74	1.30	.06	.45	.021	.179	.200
1242	54	do	98.53	1.47	.18	.41	.47	.88	.07	.34	.029	.131	.160
895	18	do	97.31	2.69	.21	.74	1.01	1.75	.14	.59	.034	.237	.271
		Average	98.04	1.96	.18	.56	71	1.26	.08	.45	.028	.178	.206
1379	66	Beef, round, lean, large piece	97.24	2.76	.27	.63	.81	1.44	.63	.42	.043	.202	.245
1027	19	do	97.18	2.82	.20	.86	.74	1.60	.48	.54	.032	.276	.308
1387	74	do	97.99	2.01	.47	.58	.41	.99	.18	.37	.075	.186	.261
1097	19	do	97.51	2.49	.22	.70	.84	1.54	.25	.48	.035	.224	.259
		Average	97.48	2.52	.29	.69	.70	1.39	.39	.45	.046	.222	.268
		Average Nos. 895, 1027, 1097, 1205, 1211, 1242, 1379, and 1387	97.76	2.24	.23	.63	70	1.33	.23	.45	.037	.200	.237

TABLE 130.—*Composition of original complete broth.* (*Results of experiments made in 1898–1903*)—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Percentage composition of original complete broth.										
						Organic extractives.					Nitrogen.		
			Water.	Total solid matter.	Proteid.	Nitrogenous.	Nonnitrogenous.	Total.	Fat.	Ash.	Proteid.	Nonproteid.	Total.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
892	16	Beef, round, fat	97.39	2.61	0.20	0.53	0.65	1.18	0.78	0.45	0.032	0.170	0.202
893	16	....do	97.32	2.68	.27	.50	.64	1.14	.85	.42	.043	.160	.203
1091	26	....do	97.16	2.84	.14	.60	.80	1.40	.85	.45	.022	.192	.214
1092	26	....do	97.63	2.37	.17	.50	.65	1.15	.67	.38	.027	.160	.187
1172	35	....do	97.86	2.14	.10	.37	.53	.90	.84	.30	.016	.119	.139
		Average	97.47	2.53	.18	.50	.65	1.15	.80	.40	.028	.160	.188
1093	27	Beef, "plate boil," very fat	98.21	1.79	.16	.24	.35	.59	.84	.20	.026	.077	.103
1094	27	....do	98.06	1.94	.09	.18	.34	.52	1.18	.15	.014	.058	.072
		Average	98.13	1.87	.13	.21	.35	.56	1.01	.18	.020	.068	.088
1098	29	Beef, round, rather fat	94.56	5.44	.23	.62	.98	1.60	3.12	.49	.037	.199	.236
1099	29	....do	96.29	3.71	.28	.50	.77	1.27	1.77	.39	.045	.160	.205
1146	30	....do	97.13	2.87	.15	.69	.91	1.60	.62	.50	.024	.221	.245
1147	30	....do	97.79	2.21	.12	.55	.72	1.27	.39	.43	.019	.176	.195
		Average	96.44	3.56	.20	.59	.85	1.44	1.48	.45	.031	.189	.220
1160	32	Beef, "plate boil," very fat	93.89	6.11	.13	.23	.34	.57	5.24	.17	.021	.074	.095
1161	32	....do	90.51	9.49	.10	.29	.43	.72	8.45	.22	.016	.093	.109
1162	33	Beef, neck, very fat	98.18	1.82	.15	.26	.39	.65	.83	.19	.024	.083	.107
1163	33	....do	98.88	1.12	.12	.22	.31	.53	.31	.16	.019	.071	.090
1169	34	Beef, ribs, very fat	95.89	4.11	.16	.35	.47	.82	2.88	.25	.026	.112	.138
1170	34	....do	96.07	3.93	.14	.30	.38	.68	2.90	.21	.022	.096	.118
		Average of above	95.57	4.43	.13	.28	.39	.66	3.44	.20	.021	.088	.109
1177	38	Veal, leg	97.39	2.61	.41	.45	.63	1.08	.78	.34	.066	.144	.210
1178	38	....do	98.30	1.70	.38	.39	.50	.89	.13	.30	.061	.125	.186
1181	40	....do	97.78	2.22	.40	.48	.81	1.29	.15	.38	.061	.154	.218
1182	40	....do	98.29	1.71	.42	.37	.56	.93	.06	.30	.067	.119	.186
		Average	97.94	2.06	.40	.42	.63	1.05	.28	.33	.064	.136	.200
1179	39	Mutton, leg	89.73	10.27	.22	.61	.77	1.38	8.25	.42	.035	.196	.231
1180	39	....do	92.70	7.30	.29	.55	.78	1.33	5.31	.37	.046	.176	.222
1183	41	....do	93.65	6.35	.15	.44	.87	1.31	4.50	.39	.024	.141	.165
1184	41	....do	91.40	8.60	.19	.37	.75	1.12	6.95	.34	.030	.119	.149
		Average	91.87	8.13	.21	.49	.79	1.29	6.25	.38	.034	.158	.192
1173	36	Pork, fresh ham	98.50	1.50	.15	.27	.39	.66	.47	.22	.024	.087	.111
1174	36	....do	94.32	5.68	.10	.33	.48	.81	4.53	.24	.016	.106	.122
1175	37	....do	97.51	2.49	.05	.33	.43	.76	1.42	.26	.008	.106	.114
1176	37	....do	96.95	3.05	.07	.34	.46	.80	1.91	.27	.011	.109	.120
		Average	96.82	3.18	.09	.32	.44	.76	2.08	.25	.015	.102	.117
1159	31	Beef, round, lean	96.95	......	......	......	......	......	1.00	.63	......	......	......
1206	48	....do	97.40	2.60	.13	.79	1.03	1.82	.05	.60	.021	.253	.274
1212	51	....do	97.40	2.60	.24	.67	.82	1.49	.32	.55	.038	.215	.253
1243	54	....do	97.81	2.19	.23	.60	.65	1.25	.24	.47	.037	.192	.229
		Average	97.39	2.46	.20	.69	.83	1.52	.40	.56	.032	.220	.252
820a	24	Beef, round, lean	97.72	2.28	.72	.44	.60	1.04	.15	.37	.115	.141	.256
820b	24	....do	96.90	3.10	1.03	.57	.83	1.40	.20	.47	.165	.183	.348
		Average	97.31	2.69	.88	.51	.72	1.22	.18	.42	.140	.162	.302
1376	63	Beef, round, lean, one piece	97.45	2.55	.75	.56	.64	1.20	.05	.55	.120	.179	.299
1384	71	....do	96.99	3.01	.94	.69	.80	1.49	.09	.49	.150	.221	.371
		Average	97.22	2.78	.85	.63	.72	1.35	.07	.52	.135	.200	.335

TABLE 130. *Composition of original complete broth. (Results of experiments made in 1898-1903)*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Percentage composition of original complete broth.										
			Water.	Total solid matter.	Proteid.	Organic extractives.			Fat.	Ash.	Nitrogen.		
						Nitrogenous.	Nonnitrogenous.	Total.			Proteid.	Nonproteid.	Total.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1377	64	Beef, round, lean, one piece	97.79	2.21	0.61	0.50	0.58	1.08	0.13	0.39	0.098	0.160	0.258
1385	72	....do	97.96	2.04	.64	.42	.47	.89	.20	.31	.102	.135	.237
		Average	97.87	2.13	.63	.46	.53	.99	.17	.35	.100	.148	.248
1368	59	Beef, round, ½-inch cubes	96.89	3.11	52	.84	.98	1.82	.16	.61	.083	.269	.352
1380	67	....do	97.25	2.75	1.20	.46	.24	.70	.19	.66	.192	.147	.339
		Average	97.07	2.93	.86	.65	.61	1.26	.18	.64	.138	2.08	.346
1369	60	Beef, round, ½-inch cubes	97.10	2.90	.88	.67	.69	1.36	.16	.50	.141	.215	.356
1381	68	....do	97.04	2.96	.82	.70	.82	1.52	.15	.47	.131	.224	.355
		Average	97.07	2.93	.85	.69	.76	1.44	.16	.49	.136	.220	.356
		Average Nos. 1368, 1369, 1376, 1377, 1380, 1381, 1384, and 1385	97.31	2.69	.80	.61	.65	1.26	.14	.50	.127	.194	.321
1171	35	Beef, round, lean	98.06	1.94	.17	.41	.55	.96	.46	.35	.027	.131	.158
771a	17	....do	96.50	3.50	.30	.78	1.05	1.83	.80	.57	.048	.250	.298
771b	17	....do	96.05	3.95	.38	.76	1.07	1.83	1.15	.59	.061	.244	.305
823a	25	....do	97.17	2.83	.36	.78	.99	1.77	.12	.58	.058	.250	.308
823b	25	....do	96.90	3.10	.34	.74	.96	1.70	.51	.55	.054	.237	.291
		Average Nos. 771a, 771b, 823a, and 823b	96.65	3.35	.35	.77	1.02	1.78	.65	.57	.055	.245	.300
		Average of 72 samples	96.64	3.36	.33	.58	.74	1.32	1.25	.45	.052	.186	.237
		Maximum	98.88	10.27	1.20	.94	1.17	2.06	8.45	.74	1.92	.285	.375
		Minimum	89.73	1.12	.05	.18	.24	.52	.03	.15	.011	.058	.072

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Composition of complete broth. (Water-free substance).					
			Proteid	Organic extractives.			Fat.	Ash.
				Nitrogenous.	Nonnitrogenous.	Total.		
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1158	31	Beef, round, lean	7.07	25.54	37.50	63.04	10.87	19.01
1095	28	....do	4.67	17.06	24.53	41.59	39.25	14.49
1096	28	....do	5.14	17.06	23.36	40.42	40.89	13.55
		Average Nos. 1095 and 1096	4.91	17.06	23.95	41.01	40.07	14.02
1370	61	Beef, round, lean, ½-inch cubes	12.44	18.89	24.20	43.09	29.03	15.44
1382	69	....do	4.12	25.82	30.49	56.32	21.98	17.58
		Average	8.28	22.36	27.35	49.71	25.51	16.51
1371	62	Beef, round lean, ½-inch cubes	12.38	19.39	22.90	42.29	31.07	14.25
1383	70	....do	17.75	21.10	25.18	46.28	21.35	14.63
		Average	15.07	20.25	24.04	44.29	26.21	14.44
		Average Nos. 1370, 1371, 1382, and 1383	11.67	21.30	25.69	46.99	25.86	15.48

TABLE 130.—*Composition of original complete broth. (Results of experiments made in 1898–1903)*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Composition of complete broth. (Water-free substance.)					
				Organic extractives.				
			Proteid.	Nitrogenous.	Non-nitrogenous.	Total.	Fat.	Ash.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
894	18	Beef, round, lean, small piece	6.50	27.55	36.22	63.78	6.81	22.91
779b	21	do	13.48	21.56	27.76	49.33	19.14	18.06
809b	23	do	4.64	22.90	32.17	55.07	21.45	18.84
781b	22	do	11.39	23.73	31.01	54.74	13.92	19.94
		Average	9.00	23.94	31.79	55.73	15.33	19.94
1378	65	Beef, round, lean, small piece	4.05	21.97	23.70	45.67	31.79	18.50
779a	21	do	11.75	19.06	24.02	43.08	28.43	16.71
1386	73	do	11.85	23.13	28.03	51.16	17.63	19.34
809a	23	do	5.25	19.89	27.62	47.51	30.11	17.13
781a	22	do	11.20	18.77	28.57	47.34	24.37	17.09
777a	20	do	10.15	20.00	27.16	47.16	24.48	18.21
777b	20	do	10.96	20.82	26.30	47.12	24.93	16.99
		Average	9.32	20.52	26.49	47.01	25.96	17.71
		Average Nos. 777a, 777b, 779a, 779b, 781a 781b 809a, 809b 894, 1378, and 1386	9.20	21.76	28.42	50.18	22.10	18.52
1211	51	Beef, round, lean, large piece	10.46	29.65	34.88	64.53	1.74	23.26
1205	48	do	6.70	28.87	38.14	67.01	3.09	23.20
1242	54	do	12.24	27.82	31.97	59.79	4.76	23.14
895	18	do	7.81	27.51	37.55	65.06	5.20	21.93
		Average	9.30	28.46	35.63	64.10	3.70	22.88
1379	66	Beef, round, lean, large piece	9.78	22.83	29.35	52.18	22.83	15.22
1027	19	do	7.09	30.50	26.24	56.74	17.02	19.15
1387	74	do	23.38	28.86	20.40	49.26	8.96	18.41
1097	19	do	8.84	28.11	33.73	61.84	10.04	19.28
		Average	12.27	27.58	27.43	55.01	14.71	18.02
		Average Nos. 895, 1027, 1097, 1205, 1211, 1242, 1379, and 1387	10.79	28.02	31.53	59.55	9.21	20.45
892	16	Beef, round, fat	7.66	20.31	24.90	45.21	29.89	17.24
893	16	do	10.07	18.66	23.88	42.54	31.72	15.67
1091	26	do	4.93	21.13	28.17	49.30	29.97	15.85
1092	26	do	7.17	21.10	27.42	48.52	28.27	16.03
1172	35	do	4.67	17.29	24.77	42.06	39.25	14.02
		Average	6.90	19.70	25.83	45.53	31.62	15.76
1093	27	Beef, "plate boil," very fat	8.94	13.41	19.55	32.96	46.93	11.17
1094	27	do	4.64	9.28	17.53	26.81	60.84	7.73
		Average	6.79	11.35	18.54	29.89	53.89	9.45
1098	29	Beef, round, rather fat	4.23	11.38	18.02	29.41	57.35	9.01
1099	29	do	7.55	13.48	20.75	34.23	47.71	10.51
1146	30	do	5.23	24.04	31.71	55.75	21.60	17.42
1147	30	do	5.43	24.89	32.58	57.46	17.65	19.46
		Average	5.61	18.45	25.77	44.21	36.08	14.10
1160	32	Beef, "plate boil," very fat	2.13	3.76	5.56	9.33	85.76	2.78
1161	32	do	1.05	3.06	4.53	7.59	89.04	2.32
1162	33	Beef, neck, very fat	8.24	14.29	21.43	35.72	45.60	10.44
1163	33	do	10.71	10.64	27.68	47.32	27.68	14.28
1169	34	Beef, ribs, very fat	3.89	8.52	11.44	19.95	70.07	6.09
1170	34	do	3.56	7.63	9.67	17.30	73.79	5.35
		Average of above	4.93	9.48	13.39	22.87	65.32	6.88
1177	38	Veal, leg	15.71	17.24	24.14	41.38	29.88	13.03
1178	38	do	22.35	22.94	29.41	52.35	7.65	17.65
1181	40	do	18.02	21.62	36.49	58.11	6.76	17.12
1182	40	do	24.56	21.64	32.75	54.39	3.51	17.54
		Average	20.16	20.86	30.70	51.56	11.95	16.34

TABLE 130.—*Composition of original complete broth. (Results of experiments made in 1898–1903)*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Composition of complete broth. (Water-free substance.)					
				Organic extractives.				
			Proteid.	Nitrogenous.	Non-nitrogenous.	Total.	Fat.	Ash.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1179	39	Mutton, leg	2.14	5.94	7.50	13.44	80.33	4.09
1180	39	....do	3.97	7.53	10.69	18.22	72.74	5.07
1183	41	....do	2.36	6.93	13.70	20.63	70.87	6.14
1184	41	....do	2.21	4.30	8.72	13.02	80.81	3.95
		Average	2.67	6.18	10.15	16.33	76.19	4.81
1173	36	Pork, fresh ham	10.00	18.00	26.00	44.00	31.33	14.67
1174	36	....do	1.76	5.84	8.45	14.26	79.75	4.23
1175	37	....do	2.01	13.25	17.27	30.52	57.03	10.44
1176	37	....do	2.30	11.15	15.08	26.23	62.62	8.85
		Average	4.02	12.05	16.70	28.75	57.68	9.55
1159	31	Beef, round, lean	....	....	....	....	....	....
1206	48	....do	5.00	30.39	39.62	70.00	1.92	23.08
1212	51	....do	9.23	25.77	31.54	57.31	12.31	21.15
1243	54	....do	10.50	27.40	29.68	57.08	10.96	21.46
		Average	8.24	27.85	33.61	61.46	8.40	21.90
820a	24	Beef, round, lean	31.58	19.30	26.31	45.61	6.58	16.23
820b	24	....do	33.23	18.39	26.78	45.16	6.45	15.16
		Average	32.41	18.85	26.55	45.39	6.52	15.70
1376	63	Beef, round, lean, one piece	29.41	21.96	25.10	47.06	1.96	21.57
1384	71	....do	32.23	22.92	26.58	49.50	2.99	16.28
		Average	30.82	22.44	25.84	48.28	2.48	18.93
1377	64	Beef, round, lean, one piece	27.60	22.62	26.24	48.87	5.88	17.65
1385	72	....do	31.37	20.59	23.04	43.63	9.80	15.20
		Average	29.49	21.61	24.64	46.25	7.84	16.43
1368	59	Beef, round, ½-inch cubes	16.72	27.01	31.51	58.52	5.15	19.61
1380	67	....do	43.64	16.73	8.73	25.45	6.91	24.00
		Average	30.18	21.87	20.12	41.99	6.03	21.81
1369	60	Beef, round, ½-inch cubes	30.34	23.10	23.79	46.90	5.52	17.24
1381	68	....do	27.70	23.65	27.70	51.35	5.07	15.88
		Average	29.02	23.38	25.75	49.13	5.30	16.56
		Average Nos. 1368, 1369 1376, 1377, 1380 1381, 1384, and 1385	29.85	22.32	24.09	46.41	5.41	18.43
1171	35	Beef, round, lean	8.74	21.13	28.33	49.46	23.76	18.04
771a	17	....do	8.57	22.29	30.00	52.29	22.86	16.29
771b	17	....do	9.62	19.24	27.09	46.33	29.11	14.94
823a	25	....do	12.72	27.56	34.98	62.54	4.24	20.50
823b	25	....do	10.97	23.87	30.97	54.84	16.45	17.74
		Average Nos. 771a, 771b, 823a, and 823b	10.47	23.24	30.76	54.00	18.17	17.37
		Average of 73 samples	11.54	19.51	24.91	44.42	28.68	15.38
		Maximum	43.64	30.50	39.62	70.00	89.04	24.00
		Minimum	1.05	3.06	4.53	7.59	1.74	2.32

NOTE.—Experiment No. 31 not included in average.

TABLE 131.—*Composition of original complete broth. (Results of experiments made in 1903–1904.)*

[Calculated to the basis, 100 grams of meat give 100 grams of broth, or 1 pound of meat gives 1.04 pints of broth.]

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Amount taken.	Fat in cooked meat.	Method of cooking.		
					Temperature.		Duration of cooking.
					At beginning.	During cooking	
			Grams.	*Per cent.*	°*C.*	°*C.*	*Hours.*
1642	109	Beef, round, 1-inch cubes	1,000	3.93	Cold.	85	3
1754	137	Beef, round, 2-inch cubes	900	6.80	Cold.	85	3
		Average		5.37	Cold.	85	3
1756	139	Beef, round, browned, 2-inch cubes	900	8.00	Cold.	85	3
		Average Nos. 1642, 1754, and 1756		6.24	Cold.	85	3
1746	136	Beef, round, browned, 2-inch cubes	1,000	7.12	85	85	3
1769	145	Beef, round, 2-inch cubes	1,074.83	6.87	85	85	3
1780	154	.....do	1,052.17	6.62	85	85	3
		Average		6.75	85	85	3
		Average Nos. 1746, 1769, and 1780		6.87	85	85	3
1641	108	Beef, round, 1-inch cubes	1,000	4.38	100	85	3
1744	134	Beef, round, 2-inch cubes	1,000	4.83	100	85	3
		Average		4.61	100	85	3
1768	144	Beef, round, 1 piece	1,027.72	7.51	100	85	3
1779	153	.....do	1,098.31	7.88	100	85	3
		Average		7.70	100	85	3
		Average Nos. 1641, 1744, 1768, and 1779		6.15	100	85	3
1755	138	Beef, round, 2-inch cubes	900	7.35	Cold.	100	3
1757	140	Beef, round, browned, 2-inch cubes	900	6.83	Cold.	100	3
		Average		7.09	Cold.	100	3
1743	133	Beef, round, 2-inch cubes	1,000	5.06	100	100	3
1745	135	Beef, round, browned, 2-inch cubes	1,000	7.74	100	100	3
		Average		6.40	100	100	3
		Average of all cooked 3 hours		6.49			3
1646	113	Beef, round, ¾-inch cubes	1,000	5.57	Cold.	65	5
1645	112	Beef, round, ¾-inch cubes	1,000	5.23	Cold.	85	5
1654	116	Veal, leg, 1-inch cubes	1,000	.97	Cold.	85	5
1658	118	.....do	1,000	5.58	Cold.	85	5
		Average Nos. 1654 and 1658		3.28	Cold.	85	5
		Average Nos. 1645, 1654, and 1658		3.93	Cold.	85	5
1644	111	Beef, round, ¾-inch cubes	1,000	5.75	100	85	5
1720	131	Beef, round, 1-inch cubes	1,000	11.61	100	85	5
		Average		8.68	100	85	5
1665	121	Beef, neck, ¾-inch cubes	700	13.68	100	85	5
1673	123	Beef, rump, 1-inch cubes	1,000	42.03	100	85	5
1703	125	.....do	1,000	23.36	100	85	5
		Average		32.70	100	85	5
1669	122	Beef, flank, fat ¾-inch cubes	1,000	34.16	100	85	5
1653	115	Veal leg, 1-inch cubes	1,000	1.31	100	85	5
1664	117	.....do	1,000	7.77	100	85	5
		Average		4.54	100	85	5
		Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720		17.46	100	85	5

TABLE 131.—*Composition of original complete broth.* (*Results of experiments made in 1903–1904*)—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Amount taken.	Fat in cooked meat.	Method of cooking.		
					Temperature.		Duration of cooking.
					At beginning.	During cooking.	
			Grams.	*Per cent.*	°*C.*	°*C.*	*Hours.*
1639	107	Beef, round, 1-inch cubes	1,000	....	100	100	5
1643	110	Beef, round, ¾-inch cubes	1,000	5.66	100	100	5
1721	132	Beef, round, 1-inch cubes	1,000	9.01	100	100	5
		Average	....	7.34	100	100	5
1704	126	Beef, rump, 1-inch cubes	1,000	16.07	100	100	5
1652	114	Veal, leg, 1-inch cubes	1,000	1.59	100	100	5
		Average Nos. 1639, 1643, 1652, 1704, and 1721	....	8.08	100	100	5
		Average of all cooked 5 hours	....	11.83	....	....	5
		Average of all cooked 3 and 5 hours	....	9.34	....	....	....
		Maximum	1,098.31	42.03	....	....	....
		Minimum	700.00	.97	....	....	....

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Percentage composition of original complete broth.										
			Water.	Total solid matter.	Proteid.	Organic extractives.			Fat.	Ash.	Nitrogen.		
						Nitrogenous.	Nonnitrogenous.	Total.			Proteid.	Nonproteid.	Total.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1642	109	Beef, round, 1-inch cubes	94.716	5.284	1.557	1.021	1.339	2.360	0.594	0.773	0.249	0.327	0.576
1754	137	Beef, round, 2-inch cubes	96.080	3.920	.541	.862	1.056	1.918	.863	.598	.087	.276	.363
		Average	95.398	4.602	1.049	.942	1.198	2.139	.729	.686	.168	.302	.470
1756	139	Beef, round, browned, 2-inch cubes	96.555	3.445	.319	.871	1.059	1.930	.584	.613	.051	.279	.330
		Average Nos. 1642, 1754, and 1756	95.784	4.216	.806	.918	1.151	2.069	.680	661	.129	.294	.423
1746	136	Beef, round, browned, 2-inch cubes	95.501	4.499	.345	.835	1.095	1.930	1.618	.605	.055	.268	.323
1769	145	Beef, round, 2-inch cubes	97.214	2.786	.245	.751	.833	1.584	.437	.520	.039	.241	.280
1780	154	.....do	......	......	.249	.732	.896	1 628	......	.526	.040	.234	.274
		Average	97.214	2.786	.247	.742	.865	1.606	.437	.523	.040	.238	.277
		Average Nos. 1746, 1769, and 1780	96.358	3.643	.280	.773	.941	1.714	1.028	.550	.045	.248	.292
1641	108	Beef, round, 1-inch cubes	95.570	4.430	.642	1.063	1.359	2.422	.609	.757	.103	.341	.444
1744	134	Beef, round, 2-inch cubes	96.688	3.312	.332	.868	1.186	2.054	.313	.614	.053	.278	.331
		Average	96.129	3.871	.487	.966	1.273	2.238	.461	.686	.078	.310	.388
1768	144	Beef, round, 1 piece	97.759	2.241	.201	.672	.734	1.406	.171	.462	.032	.216	.248
1779	153	.....do	97.275	2.725	.185	.735	.874	1.609	.415	.516	.030	.265	.295
		Average	97.517	2.483	.193	.704	.804	1.508	.293	.489	.031	.241	.272
		Average Nos. 1641, 1744, 1768, and 1779	96.823	3.177	.340	.835	1.038	1.873	.377	.587	.055	.275	.330

TABLE 131.—*Composition of original complete broth. (Results of experiments made in 1903–1904)*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Percentage composition of original complete broth.										
			Water.	Total solid matter.	Proteid.	Organic extractives.			Fat.	Ash.	Nitrogen.		
						Nitrogenous.	Nonnitrogenous.	Total.			Proteid.	Nonproteid.	Total.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1755	138	Beef, round, 2-inch cubes	95.227	4.773	0.574	0.890	1.062	1.952	1.615	0.633	0.092	0.285	0.377
1757	140	Beef, round, browned, 2-inch cubes	96.369	3.631	.371	.892	1.083	1.975	.649	.636	.059	.286	.345
		Average	95.798	4.202	.473	.891	1.073	1.964	1.132	.635	.076	.286	.361
1743	133	Beef, round, 2-inch cubes	96.531	3.469	.394	.887	1.110	1.997	.457	.622	.063	.284	.347
1745	135	Beef, round, browned, 2-inch cubes	94.637	5.363	.429	.820	1.066	1.886	2.479	.570	.069	.262	.331
		Average	95.584	4.416	.412	.854	1.088	1.942	1.468	.596	.066	.273	.339
		Average of all cooked 3 hours	96.163	3.837	.456	.850	1.054	1.904	.877	.603	.073	.274	.348
1646	113	Beef, round, ¾-inch cubes	95.544	4.456	.906	.918	1.194	2.112	.700	.738	.145	.294	.439
1645	112	Beef, round, ¾-inch cubes	95.077	4.923	.801	.990	1.267	2.257	1.142	.724	.128	.318	.446
1654	116	Veal, leg, 1-inch cubes	96.283	3.717	1.012	.756	1.137	1.893	.188	.624	.162	.242	.404
1658	118	do	96.097	3.903	1.022	.791	.960	1.751	.498	.633	.164	.253	.417
		Average Nos. 1654 and 1658	96.190	3.810	1.017	.774	1.049	1.822	.343	.629	.163	.248	.411
		Average Nos. 1645, 1654, and 1658	95.819	4.181	.945	.846	1.121	1.967	.609	.660	.151	.271	.422
1644	111	Beef, round, ¾-inch cubes	95.775	4.225	.564	.916	1.195	2.111	.850	.699	.090	.294	.384
1720	131	Beef, round, 1-inch cubes	95.388	4.612	.424	.949	1.336	2.285	1.264	.639	.068	.304	.372
		Average	95.582	4.419	.494	.933	1.266	2.198	1.057	.669	.079	.299	.378
1665	121	Beef, neck, ¾-inch cubes	......	......	......	......	......	......	1.017	.671	......	......	.335
1673	123	Beef, rump, 1-inch cubes	91.218	8.782	.506	.605	.855	1.460	6.320	.497	.081	.194	.275
1703	125	do	94.712	5.288	.445	.863	1.027	1.890	2.359	.594	.071	.277	.348
		Average	92.965	7.035	.476	.734	.941	1.675	4.340	.546	.076	.236	.312
1669	122	Beef, flank, fat, ¾-inch cubes	91.082	8.918	.701	.561	.738	1.299	6.481	.437	.112	.180	.292
1653	115	Veal, leg, 1-inch cubes	96.832	3.168	.510	.847	1.131	1.978	.057	.624	.082	.272	.354
1664	117	do	96.728	3.272	.636	.777	.912	1.689	.331	.616	.102	.249	.351
		Average	96.780	3.220	.573	.812	1.022	1.834	.194	.620	.092	.261	.353
		Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	94.534	5.466	.541	.788	1.028	1.816	2.335	.597	.087	.253	.339
1639	107	Beef, round, 1-inch cubes	95.940	4.060	.515	.888	1.250	2.138	.742	.666	.082	.285	.367
1643	110	Beef, round, ¾-inch cubes	95.929	4.071	.618	.876	1.092	1.968	.848	.638	.099	.280	.379
1721	132	Beef, round, 1-inch cubes	95.415	4.585	.705	.881	1.274	2.155	1.135	.591	.113	.282	.395
		Average	95.761	4.239	.613	.882	1.205	2.087	.908	.632	.098	.282	.380

TABLE 131.—*Composition of original complete broth. (Results of experiments made in 1903-1904)*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Percentage composition of original complete broth.										
			Water	Total solid matter.	Proteid.	Organic extractives.			Fat.	Ash.	Nitrogen.		
						Nitrogenous.	Nonnitrogenous.	Total.			Proteid.	Nonproteid.	Total.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct*	*P. ct.*	*P. ct.*	*P. ct.*
1701	126	Beef, rump, 1-inch cubes	93.689	6.311	1.011	0.745	0.940	1.685	3.087	0.528	0.162	0.239	0.401
1652	114	Veal, leg, 1-inch cubes	97.115	2.885	.681	.668	.958	1.626	.068	.509	.109	.214	.323
		Average Nos. 1639, 1643, 1652, 1701, and 1721	95.617	4.383	0.706	0.812	1.103	1.911	1.176	0.586	0.113	0.260	0.373
		Average of all cooked 5 hours	95.177	4.823	.691	.814	1.079	1.893	1.593	.613	.111	.261	.370
		Average of all cooked 3 and 5 hours	95.619	4.381	.581	.831	1.067	1.898	1.263	.609	.093	.267	.360
		Maximum	97.759	8.918	1.557	1.063	1.359	2.422	6.481	.773	.249	.341	.576
		Minimum	91.082	2.241	.185	.561	.734	1.299	.057	.437	.030	.180	.248

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Composition of water-free substance of entire complete broth.					
			Proteid.	Organic extractives.			Fat.	Ash.
				Nitrogenous.	Nonnitrogenous.	Total.		
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1642	109	Beef, round, 1-inch cubes	29.47	19.32	25.34	44.66	11.24	14.63
1754	137	Beef, round, 2-inch cubes	13.80	21.99	26.94	48.93	22.02	15.25
		Average	21.64	20.66	26.14	46.80	16.63	14.94
1756	139	Beef, round, browned, 2-inch cubes	9.26	25.28	30.74	56.02	16.95	17.79
		Average Nos. 1642, 1754, and 1756	17.51	22.20	27.67	49.87	16.74	15.89
1746	136	Beef, round, browned, 2-inch cubes	7.67	18.56	24.34	42.90	35.96	13.45
1769	145	Beef, round, 2-inch cubes	8.79	26.96	29.90	56.86	15.69	18.66
1780	154	do	....	....	....	....	....	....
		Average	....	....	....	....	....	....
		Average Nos. 1746, 1769, and 1780	8.23	22.76	27.12	49.88	25.83	16.06
1641	108	Beef, round, 1-inch cubes	14.49	24.00	30.68	54.67	13.75	17.09
1744	134	Beef, round, 2-inch cubes	10.02	26.20	35.81	62.01	9.45	18.54
		Average	12.26	25.10	33.25	58.34	11.60	17.82
1768	144	Beef, round, 1 piece	8.97	29.99	32.75	62.74	7.63	20.62
1779	153	do	6.79	26.97	32.07	59.04	15.23	18.94
		Average	7.88	28.48	32.41	60.89	11.43	19.78
		Average Nos. 1641, 1744, 1768, and 1779	10.07	26.79	32.83	59.62	11.52	18.80
1755	138	Beef, round, 2-inch cubes	12.03	18.65	22.25	40.90	33.84	13.26
1757	140	Beef, round, browned, 2-inch cubes	10.22	24.57	29.83	54.40	17.87	17.52
		Average	11.13	21.61	26.04	47.65	25.86	15.39

Table 131.—*Composition of original complete broth.* (*Results of experiments made in 1903-1904*)—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat used for cooking.	Composition of water-free substance of entire complete broth. Proteid.	Organic extractive. Nitrogenous.	Organic extractive. Non-nitrogenous.	Organic extractive. Total.	Fat.	Ash.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1743	133	Beef, round, 2-inch cubes	11.36	25.57	32.00	57.57	13.17	17.93
1745	135	Beef, round, browned, 2-inch cubes	8.00	15.29	19.88	35.17	46.22	10.63
		Average	9.68	20.43	25.94	46.37	29.70	14.28
		Average of all cooked 3 hours	11.61	23.34	28.66	51.99	19.92	16.49
1646	113	Beef, round, ¾-inch cubes	20.33	20.60	26.80	47.40	15.71	16.56
1645	112	Beef, round, ¾-inch cubes	16.27	20.11	25.74	45.85	23.20	14.76
1654	116	Veal, leg, 1-inch cubes	27.25	20.34	30.59	50.93	5.06	16.79
1658	118	.....do	26.18	20.27	24.60	44.86	12.75	16.22
		Average Nos. 1654 and 1658	26.72	20.31	27.60	47.90	8.91	16.51
		Average, Nos. 1645, 1654, and 1658	23.23	20.24	26.98	47.21	13.67	15.92
1644	111	Beef, round, ¾-inch cubes	13.35	21.68	28.28	49.96	20.12	16.54
1720	131	Beef, round, 1-inch cubes	9.19	20.58	28.96	49.54	27.41	13.79
		Average	11.27	21.13	28.62	49.75	23.77	15.17
1665	121	Beef, neck, ¾-inch cubes	....	....	....	....	....	....
1673	123	Beef, rump, 1-inch cubes	5.76	6.89	9.74	16.63	71.97	5.66
1703	125	.....do	8.42	16.32	19.42	35.74	44.61	11.23
		Average	7.09	11.61	14.58	26.19	58.29	8.45
1669	122	Beef, flank, fat, ¾-inch cubes	7.86	6.29	8.28	14.57	72.67	4.90
1653	115	Veal, leg, 1-inch cubes	16.10	26.74	35.70	62.44	1.80	19.70
1664	117	.....do	19.44	23.75	27.87	51.62	10.12	18.83
		Average	17.77	25.25	31.79	57.03	5.96	19.27
		Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720.	11.45	17.47	22.61	40.07	35.53	12.95
1639	107	Beef, round, 1-inch cubes	12.68	21.87	30.79	52.66	18.27	16.40
1643	110	Beef, round, ¾-inch cubes	15.18	21.52	26.82	48.34	20.83	15.64
1721	132	Beef, round, 1-inch cubes	15.38	19.21	27.79	47.00	24.75	12.89
		Average	14.41	20.87	28.47	49.33	21.28	14.98
1704	126	Beef, rump, 1-inch cubes	16.02	11.80	14.89	26.70	48.91	8.37
1652	114	Veal, leg, 1-inch cubes	23.60	23.15	33.21	56.36	2.36	17.64
		Average Nos. 1639, 1643, 1652, 1704, and 1721	16.57	19.51	26.70	46.21	23.02	14.19
		Average of all cooked 5 hours	15.81	18.82	24.97	43.79	26.28	14.12
		Average of all cooked 3 and 5 hours	13.93	20.85	26.62	47.46	23.43	15.18
		Maximum	29.47	29.99	35.81	62.74	72.67	20.62
		Minimum	5.76	6.29	8.28	14.57	1.80	4.90

By referring to Table 130, page 189, it will be seen that the average composition of the 72 samples of meat broths, calculated to a common basis (100 grams of meat per 100 grams of broth, or 1 pound of meat per 1.04 pints of broth) was 96.64 per cent water, 3.36 per cent total solids, 0.33 per cent proteid, 0.58 per cent nitrogenous extractives, 0.74 per cent nonnitrogenous extractives, 1.32 per cent total organic extractives, 1.25 per cent fat, and 0.45 per cent ash. The average amount of total nitrogen was 0.237 per cent, of which 0.052 per cent existed in proteid and 0.186 per cent in nonproteid form.

The total solid matter in the broths varied from 1.12 per cent to 10.27 per cent of the weight of the meat used. The smallest amount was found in broth No. 1163, from cooking experiment No. 33, in which a large piece of very fat beef neck was cooked at 100° C. for ten minutes and then at 80 to 85° C. for three hours. The total solids were composed of 0.12 per cent proteid, 0.22 per cent nitrogenous extractives, 0.31 per cent nonnitrogenous extractives, 0.53 per cent total organic extractives, 0.31 per cent fat and 0.16 per cent ash. Calculated to water-free basis, this broth residue had the following percentage composition: Proteid 10.71, nitrogenous extractives 10.64, nonnitrogenous extractives 27.68, total organic extractives 47.32, fat 27.68, and ash 14.28 per cent.

The largest quantity of solid matter was found in broth No. 1179, from cooking experiment No. 39, in which a small piece of leg of mutton was cooked at 100° C. for ten minutes and then at 80° to 85° C. for three hours. The 10.27 per cent total solids consisted of 0.22 per cent proteid, 0.61 per cent nitrogenous extractives, 0.77 per cent nonnitrogenous extractives, 8.25 per cent fat, and 0.42 per cent ash. Calculated to a water-free basis, the percentage composition was: Proteid 2.14, nitrogenous extractives 5.94, nonnitrogenous extractives 7.50, total organic extractives 13.44, fat 80.33, and ash 4.09 per cent.

The richness of broth, as measured by the total solids which it contains, seems to depend largely upon the sizes of the pieces of meat which are cooked. In other words, the smaller or the more finely divided the pieces of meat used, the richer the resulting broth. This may be readily noted in the detailed results given in Table 130.

The average amount of solid matter in the four broths (Nos. 1370, 1382, 1371, and 1383) for the preparation of which lean beef round, cut into one-half inch cubes, was cooked for ten minutes at 100° C. and for two hours at 80 to 85° C. was equal to 4.11 per cent of the weight of the meat taken for cooking. The average solid substances contained in the eleven broths, reported on page 187, for the preparation of which lean beef round, in small pieces weighing about 1.5 pounds, was cooked for ten minutes at 100° C. and for two hours at from 80 to 85° C. was equal to 3.50 per cent of the weight of the meat taken for cooking. The average quantity of total solid material in the last eight broths listed upon page 187, which were prepared by cooking large pieces of beef round, weighing on the average almost 4.5 pounds, for ten minutes at about 100° C. and then for two hours at from 80 to 85° C. was equal to only 2.24 per cent of the weight of the meat taken for cooking. Other experiments here reported confirm the conclusion expressed above, that the smaller the pieces of meat (or the more finely divided the meat) used, the richer the resulting broth.

It is commonly supposed that if meat is placed in cold water, the temperature raised gradually and the cooking then continued as usual, more of its soluble ingredients are extracted and a richer broth obtained than when it is first put into boiling water and then cooked at a somewhat lower temperature. The earlier experiments[a] made under the auspices of this Office with meats cooked in hot water did not confirm this commonly accepted opinion. On the contrary, the results indicated clearly that the temperature of the water in which the meat was placed at the start had little influence upon the amount of material found in the broth. The data in Table 130 showing the detailed composition of the complete broths calculated to a uniform basis (1 pound of meat per 1.04 pints of broth) points clearly to this same conclusion, and also shows plainly the nature of the resulting broths when prepared by the two methods. For example, in the case of the 11 broths which were prepared by cooking small pieces of lean beef round, first for ten minutes in boiling water and then for two hours at from 80 to 85° C., the average weight of meat taken in these experiments was 659.20 grams, and the cooked meat contained upon an average 8.09 per cent of fat, and the average percentage composition of the broths was: Water 96.49, total solid matter 3.50, proteid 0.32, nitrogenous extractives 0.76, nonnitrogenous extractives 0.99, total organic extractives 1.75, fat 0.78, and ash 0.65 per cent. The average amount of total nitrogen was 0.294 per cent 0.52 per cent being in proteid and 0.243 per cent in nonproteid form. Calculated to a water-free basis, these broth residues had the following average composition: Proteid 9.20, nitrogenous extractives 21.76, nonnitrogenous extractives 28.42, total organic extractives 50.18, fat 22.10 per cent, and ash 18.52 per cent.

In the case of 4 broths prepared by putting small pieces of lean beef round in cold water, raising the temperature gradually to 80° C. and continuing the cooking for two hours and forty-five minutes longer at this temperature, the average weight of meat used was 777.22 grams and the cooked meat contained on an average 6.33 per cent of fat. The average composition of the 4 broths was: Water 96.65, total solid matter 3.35, proteid 0.35, nitrogenous extractives 0.77, nonnitrogenous extractives 1.02, total organic extractives 1.78, fat 0.65, and ash 0.57 per cent. The average amount of proteid nitrogen was 0.055 per cent and of nonproteid nitrogen 0.245 per cent, or 0.300 per cent total nitrogen. Calculated to a water-free basis, these broth residues had the following average composition: Proteid 10.47, nitrogenous extractives 23.24, nonnitrogenous extractives

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[a] U. S. Dept. Agr., Office of Experiment Stations Buls. 102, 141.

30.76, total organic extractives 54.00, fat 18.17, and ash 17.37 per cent. It is apparent from these figures that there is little difference in the composition of the broths resulting from the two different methods of preparation.

When the several constituents are considered separately, some variation in the different broths is noted, but it is by no means uniform enough for general deductions.

The total proteid in the broths varied from 0.05 per cent in sample No. 1175, prepared by cooking fresh ham for ten minutes at 100° C. and then for three hours at 80 to 85° C., to 1.20 per cent in sample No. 1380, prepared by placing beef round cut into one-half inch cubes in cold water, raising the temperature slowly to 48° C. and cooking at about this temperature for five hours.

Table 130 also gives the data regarding the composition of the total solid matter of the meat broths, calculated to a water-free basis. Expressed in this form the average percentage composition of the dry matter from the 73 complete broths was: 11.54 proteid, 19.51 nitrogenous extractives, 24.91 nonnitrogenous extractives, 44.42 total organic extractives, 28.68 fat, and 15.38 per cent ash. It is of interest to compare these figures with similar data for the composition of uncooked and boiled meats. The average percentage composition of 31 samples of meats cooked in contact with hot water, expressed on a water-free basis, was: 77.07 proteid, 1.43 nitrogenous extractives, 1.84 nonnitrogenous extractives, 3.27 total organic extractives, 20.17 fat, and 1.60 per cent ash. It is thus evident that the water-free substance of broths contained about one-seventh as much proteid, seven times as much nitrogenous and nonnitrogenous extractives, and fourteen times as much total organic extractives, somewhat more fat, and more than nine times as much mineral matter as the dry matter of boiled meat.

The average composition of 11 samples of raw meats on a water-free basis was: 62.59 proteid, 3.83 nitrogenous extractives, 5.78 nonnitrogenous extractives, 30.54 fat, and 3.59 per cent ash—that is, the water-free substance of broths, as compared with the water-free substance of uncooked meats, contains over one-sixth as much proteid, about four and one-half times as much of nitrogenous extractives, nonnitrogenous extractives, and total organic extractives, one and one-fourth as much fat, and three and eight-tenths as much ash.

The quantity of ash in the water-free substance of the broths varied from 2.32 per cent in sample No. 1161, to 24 per cent in sample No. 1380, the average being 15.38 per cent.

By referring to Table 131, page 195, it will be observed that the average results obtained in the years 1903 and 1904 from the analysis of 31 samples of complete meat broths were: Water 95.619 per cent, total solid matter 4.381 per cent, proteid 0.581 per cent, nitrogenous extractives 0.831 per cent, nonnitrogenous extractives 1.067 per cent, total organic extractives 1.898 per cent, fat 1.263 per cent, and ash 0.609 per cent.

The total nitrogen was 0.360 per cent, 0.093 per cent being proteid and 0.267 per cent in nonproteid form. The considerably higher result obtained in the last series as compared with the earlier tests reported is undoubtedly due to two causes. The first is the fact that in the experiments made in 1903–4 the meats were as a rule cut into small cubes, thus presenting a large surface to the solvent action of the water in which they were cooked, while in the earlier experiments the meats were as a rule cooked in compact pieces, many of them large in size. The second factor which apparently tended to give a richer broth in the later series of experiments is the longer time of cooking to which many of the meats were subjected.

Apparently, then, increasing the length of the cooking period increases the richness of the broth. Thus the average percentage composition of 14 broths cooked for three hours was: 96.163 water, 3.837 total solid matter, 0.456 proteid, 0.850 nitrogenous extractives, 1.054 nonnitrogenous extractives, 1.904 total organic extractives, 0.877 fat, and 0.603 per cent ash.

The average percentage composition of the 17 broths cooked for five hours was: 95.177 water, 4.823 total solid matter, 0.691 proteid, 0.814 nitrogenous extractives, 1.079 nonnitrogenous extractives, 1.893 total organic extractives, 1.593 fat, and 0.613 per cent ash. Since, however, the meats which were cooked for five hours contained almost twice as much fat as those cooked for three hours, this may be responsible for the large amount of fat in this broth.

The range in the proportion of the different constituents may be readily seen from the table. Such data are interesting, though they are not uniform enough for general deductions.

Table 131, page 196, also gives the percentage composition of the complete broths upon the basis of the water-free substance. Thus stated, the average percentage composition in the case of the 31 complete broths made by cooking small pieces of meat for comparatively long periods was: 13.93 proteid, 20.85 nitrogenous extractives, 26.62 nonnitrogenous extractives, 47.46 total organic extractives, 23.43 fat, and 15.18 per cent ash. On this basis of comparison it is apparent that the total solid matter of these broths contained considerably more proteid matter and nitrogenous and nonnitrogenous organic extractives and a somewhat smaller quantity of mineral substances and fat than did the total dry substance of the broths made by cooking larger pieces of meat for shorter periods.

In this connection it should be said that the true nature of the nitrogenous and nonnitrogenous extractives of broths and of meats is as yet practically unknown. In our earlier investigations[a] upon the losses which meats sustain when cooked in hot water it was observed that the sum of the proteids, flesh bases, fat, and ash in clear broths as obtained by analysis was in all cases considerably less than the amount of total solids obtained by the direct evaporation, and this quantity of unknown extractives was designated "other substances." The proportion of the undetermined material or "other substances" ranged from 19.9 to 43.4 per cent, and averaged 34.2 per cent of the total solids of the clear broth; or, stated in another way, the proportion of unidentified substances in the broth varied from 0.3 to 1.1 per cent, and averaged 0.8 per cent of the total weight of the fresh meat.

Much time has been devoted in this laboratory to the study of undetermined substances in broths, but the publication of the detailed results is withheld until further investigations can be made. It is evident from the experimental results so far obtained that this material contains considerable lactic acid, some glycogen, more or less inosite and xanthin bases, and traces of acetic and butyric acids.

In the investigations reported in the later publication referred to above,[b] notwithstanding the fact that all the determinations of proteids, flesh bases, and "other substances" were carefully made, it was then considered more satisfactory in calculating the material lost in cooking meats to combine the flesh bases and the so-called "other substances" under the name of "extractives," a term which has often been used in that sense.[c]

Recent studies in connection with these nutrition investigations have shown that the cold-water extracts of meats also give results similar to those obtained in the analysis of broths, namely, that the sum of the nitrogenous matters, fat, and mineral matter determined by direct analysis is in every case decidedly less than the total solid residue obtained by direct evaporation. This difference may be seen by noting the proportion of the nonnitrogenous organic extractives in Tables 98–104, pages 99–115.

COMPOSITION OF CLEAR, FILTERED MEAT BROTHS.

The methods (see p. 15) used in the determination of the losses involved in the cooking of meats in hot water make it necessary to separate the constituents of the original complete broths into those which exist in the form of suspended matter and those which occur dissolved in the clear filtered broth. Broths are so frequently served clear that it seems desirable to present the available data regarding the composition of the filtered broths, and in Tables 132 and 133 the composition of the clear, filtered broths, calculated to the basis that 100 grams of meat per 100 grams of broth or 1 pound of meat per 1.04 pints of original broth, will be found. The kind and cut of meat and the method of cooking are plainly shown in the tables, together with the weight of meat taken, the weight of the resulting complete broth, and the weight of the clear broth. The tables also give the percentage composition of the clear, filtered broth calculated to the basis of the water-free substance.

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[a] U. S. Dept. Agr., Office of Experiment Stations Buls. 102, 141.

[b] U. S. Dept. Agr., Office of Experiment Stations Bul. 141.

[c] Mitchell's Flesh Foods, pp. 7, 45, and 48. See also Allen's Commercial Organic Analysis, vol. 4, Philadelphia, 1898, pp. 270 and 335; and Halliburton's Textbook of Chemical Physiology and Pathology, 1891, p. 418.

TABLE 132. *Composition of clear, filtered broth. (Results of experiments made in 1898–1903.)*

[Calculated to the basis, 100 grams of meat give 100 grams of broth, or 1 pound of meat gives 1.04 pints of broth.]

Laboratory No.	Cooking experiment No.	Kind of meat.	Method of cooking.			Weight of meat taken.	Weight of suspended matter in broth.	Weight of clear broth.
			Temperature.		Duration of cooking.			
			At beginning.	During cooking.				
			°C.	*°C.*	*Hours.*	*Grams.*	*Grams.*	*Grams.*
1158	31	Beef, round, lean	100	80–85	1½	1,380.20	3.27	1,376.93
1095	28	.....do	100	100	2	1,211.75	21.34	1,190.41
1096	28	.....do	100	100	2	1,152.63	20.78	1,131.85
		Average Nos. 1095 and 1096	....	....	....	1,182.19	21.05	....
1370	61	Beef, round, lean, ½-inch cubes	100	80–85	2	500.00	8.03	491.97
1382	69	.....do	100	80–85	2	500.00	4.47	495.53
		Average	....	....	....	500.00	6.25	....
1371	62	Beef, round, lean, ½-inch cubes	100	80–85	2	2,500.00	43.73	2,456.27
1383	70	.....do	100	80–85	2	2,500.00	39.28	2,460.72
		Average	....	....	....	2,500.00	41.51	....
		Average Nos. 1370, 1371, 1382, and 1383	....	....	....	....	23.88	....
894	18	Beef, round, lean, small piece	100	80–85	2	433.20	1.34	431.86
779b	21	.....do	100	80–85	2	660.50	5.16	655.34
809b	23	.....do	100	80–85	2	686.60	5.36	681.24
781b	22	.....do	100	80–85	2	755.80	3.81	751.99
		Average	....	....	....	634.03	3.92	....
1378	65	Beef, round, lean, small piece	100	80–85	2	501.41	5.73	495.68
779a	21	.....do	100	80–85	2	750.00	8.59	741.41
1386	73	.....do	100	80–85	2	500.00	4.81	495.19
809a	23	.....do	100	80–85	2	742.80	8.47	734.33
781a	22	.....do	100	80–85	2	657.00	6.16	650.84
777a	20	.....do	100	80–85	2	825.80	7.32	818.48
777b	20	.....do	100	80–85	2	739.50	7.11	732.39
		Average	....	....	....	673.79	6.88	....
		Average Nos. 777a, 777b, 779a, 779b, 781a, 781b, 809a, 809b, 894, 1378, and 1386	....	....	....	659.33	5.80	....
1211	51	Beef, round, lean, large piece	100	80–85	2	2,141.09	1.39	2,139.70
1205	48	.....do	100	80–85	2	1,237.90	1.40	1,236.50
1242	54	.....do	100	80–85	2	2,108.62	2.98	2,105.64
895	18	.....do	100	80–85	2	2,080.60	4.69	2,075.91
		Average	....	....	....	1,892.05	2.62	....

Table 132.—*Composition of clear, filtered broth. (Results of experiments made in 1898–1903)*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat.	Method of cooking.			Weight of meat taken.	Weight of suspended matter in broth.	Weight of clear broth.
			Temperature.		Duration of cooking.			
			At beginning.	During cooking.				
			° C.	*° C.*	*Hours.*	*Grams.*	*Grams.*	*Grams.*
1379	66	Beef, round, lean, large piece	100	80–85	2	2,502.60	19.60	2,483.00
1027	19	.....do	100	80–85	2	2,141.25	11.54	2,129.71
1387	74	.....do	100	80–85	2	2,500.00	13.26	2,486.74
1097	19	.....do	100	80–85	2	1,139.48	3.88	1,135.60
		Average				2,070.83	12.07	....
		Average Nos. 895, 1027, 1097, 1205, 1211, 1242, 1379, and 1387				1,981.44	7.34	....
892	16	Beef, round, fat	100	80–85	2	1,220.30	10.64	1,209.66
893	16	.....do	100	80–85	2	1,477.80	14.20	1,463.60
1091	26	.....do	100	80–85	2	1,383.07	12.31	1,370.76
1092	26	.....do	100	80–85	2	1,409.64	9.97	1,399.67
1172	35	.....do	100	80–85	2	1,764.97	15.34	1,749.63
		Average				1,451.16	12.49	....
1093	27	Beef, "plate boil," very fat	100	80–85	2	2,120.13	19.53	2,100.60
1094	27	.....do	100	80–85	2	2,193.89	26.82	2,167.07
		Average				2,157.01	23.18	....
1098	29	Beef, round, rather fat	100	80–85	3	1,017.05	32.04	985.01
1099	29	.....do	100	80–85	3	1,740.51	32.92	1,707.59
1146	30	.....do	100	80–85	3	713.60	4.50	709.10
1147	30	.....do	100	80–85	3	2,323.10	9.51	2,313.59
		Average				1,448.57	19.74	....
1160	32	Beef, "plate boil," very fat	100	80–85	3	1,715.90	90.88	1,625.02
1161	32	.....do	100	80–85	3	1,825.80	154.78	1,671.02
1162	33	Beef, neck, very fat	100	80–85	3	2,393.20	20.94	2,372.26
1163	33	.....do	100	80–85	3	2,729.80	9.12	2,720.68
1169	34	Beef, ribs, very fat	100	80–85	3	1,806.37	52.74	1,753.63
1170	34	.....do	100	80–85	3	1,923.58	56.15	1,867.43
		Average of above				2,065.78	64.10	....
1177	38	Veal, leg	100	80–85	3	1,774.20	14.94	1,759.26
1178	38	.....do	100	80–85	3	2,334.70	4.26	2,330.44
1181	40	.....do	100	80–85	3	1,648.31	3.30	1,645.01
1182	40	.....do	100	80–85	3	1,939.09	2.67	1,936.42
		Average				1,924.08	6.29	....
1179	39	Mutton, leg	100	80–85	3	964.70	80.24	884.46
1180	39	.....do	100	80–85	3	1,284.20	69.47	1,214.73
1183	41	.....do	100	80–85	3	912.82	41.40	871.42
1184	41	.....do	100	80–85	3	1,268.14	88.82	1,179.32
		Average				1,107.47	69.98	....
1173	36	Pork, fresh ham	100	80–85	3	1,838.40	9.22	1,829.18
1174	36	.....do	100	80–85	3	1,608.50	73.46	1,535.04
1175	37	.....do	100	80–85	3	1,882.66	26.98	1,855.68
1176	37	.....do	100	80–85	3	2,016.70	38.93	1,977.77
		Average				1,836.57	37.15	....
1206	48	Beef, round, lean	100	80–85	5	1,210.15	1.11	1,209.04
1212	51	.....do	100	80–85	5	1,529.94	6.01	1,523.93
1243	54	.....do	100	80–85	5	1,128.00	3.53	1,124.47
		Average				1,289.36	3.55	....
		Average of 58 above				1,481.86	22.41	....
820a	24	Beef, round, lean	20–25	50	6	915.10	5.75	909.35
820b	24	.....do	20–25	50	6	837.30	6.90	830.40
		Average				876.20	6.33	....

Table 132.—*Composition of clear, filtered broth. (Results of experiments made in 1898–1903)*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat.	Method of cooking.			Weight of meat taken.	Weight of suspended matter in broth.	Weight of clear broth.
			Temperature.		Duration of cooking.			
			At beginning.	During cooking.				
			°C.	*°C.*	*Hours.*	*Grams.*	*Grams.*	*Grams.*
1376	63	Beef, round, lean, 1 piece	20–25	47–50	5	520.77	1.59	519.18
1384	71	.....do	20–25	47–50	5	500.00	2.92	497.08
		Average	....	....	....	510.39	2.26	....
1377	64	Beef, round, lean, 1 piece	20–25	47–50	5	2,384.54	9.75	2,374.79
1385	72	.....do	20 25	47–50	5	2,500.00	16.17	2,483.83
		Average	....	....	....	2,442.27	12.96	....
1368	59	Beef, round, ½-inch cubes	20–25	47–50	5	500.00	2.30	497.70
1380	67	....do	20–25	47–50	5	500.00	6.08	493.92
		Average	....	....	....	500.00	4.19	....
1369	60	Beef, round, ½-inch cubes	20–25	47–50	5	2,500.00	18.42	2,481.58
1381	68	.....do	20–25	47–50	5	2,500.00	14.67	2,485.33
		Average	....	....	....	2,500.00	16.55	....
		Average Nos. 1368, 1369, 1376, 1377, 1380, 1381, 1384, and 1385	....	....	....	1,488.16	8.99	....
1171	35	Beef, round, lean	20–25	57–60	5	1,523.68	8.35	1,515.33
771a	17	.....do	20–25	80	2¾	705.50	7.34	698.16
771b	17	.....do	20–25	80	2¾	660.80	9.54	651.26
823a	25	.....do	20–25	80	2¾	798.10	3.00	795.10
823b	25	.....do	20–25	80	2¾	944.50	6.68	937.82
		Average Nos. 771a, 771b, 823a, and 823b	....	....	....	777.23	6.64	....
		Average Nos. 771a, 771b, 820a, 820b, 823a, 823b, 1171, 1368, 1369, 1376, 1377, 1380, 1381, 1384, and 1385	....	....	....	1,219.35	7.96	....
		Average of 73 above	....	....	....	1,427.92	19.45	....
		Maximum	....	....	....	2,729.80	154.78	....
		Minimum	....	....	....	500.00	1.11	....

Laboratory No.	Cooking experiment. No.	Kind of meat.	Percentage composition of the clear, filtered broth.						Ash.
			Water.	Total solid matter.	Proteid.	Organic extractives.			
						Nitrogenous.	Non-nitrogenous..	Total.	
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1158	31	Beef round, lean	98.40	1.60	0.08	0.46	0.71	1.17	0.35
1095	28	.....do	97.43	2.57	.12	.75	1.07	1.82	.63
1096	28	.....do	97.48	2.52	.16	.75	1.02	1.77	.59
		Average Nos. 1095 and 1096	97.45	2.55	.14	.75	1.05	1.80	.61
1370	61	Beef, round, lean, ½-inch cubes	97.22	2.78	.20	.84	1.06	1.90	.68
1382	69	.....do	97.22	2.78	.06	.95	1.12	2.07	.65
		Average	97.22	2.78	.13	.89	1.09	1.98	.67

Table 132.—*Composition of clear, filtered broth. (Results of experiments made in 1898–1903)*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat.	Percentage composition of the clear, filtered broth.						
			Water.	Total solid matter.	Proteid.	Organic extractives.			Ash.
						Nitrogenous.	Non-nitrogenous.	Total.	
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1371	62	Beef, round, lean, ½-inch cubes	97.42	2.58	0.11	0.84	1.00	1.84	0.63
1383	70	.....do	97.36	2.64	.06	.89	1.07	1.96	.62
		Average	97.39	2.61	.08	.87	1.03	1.90	.63
		Average Nos. 1370, 1371, 1382, and 1383	97.30	2.70	.11	.88	1.06	1.94	.65
894	18	Beef, round, lean, small piece	97.07	2.93	.12	.90	1.18	2.08	.73
779b	21	.....do	97.05	2.95	.43	.80	1.04	1.84	.68
809b	23	.....do	97.31	2.69	.12	.80	1.12	1.92	.65
781b	22	.....do	97.33	2.67	.30	.75	.99	1.74	.63
		Average	97.19	2.81	.24	.81	1.09	1.90	.67
1378	65	Beef, round, lean, small piece	97.66	2.34	.09	.77	.83	1.60	.65
779a	21	.....do	97.28	2.72	.40	.74	.93	1.67	.65
1386	73	.....do	97.48	2.52	.06	.81	.98	1.79	.67
809a	23	.....do	97.49	2.51	.15	.73	1.01	1.74	.62
781a	22	.....do	97.34	2.66	.33	.68	1.03	1.71	.62
777a	20	.....do	97.51	2.49	.28	.68	.92	1.60	.61
777b	20	.....do	97.29	2.71	.36	.77	.96	1.73	.62
		Average	97.44	2.56	.24	.74	.95	1.69	.63
		Average Nos. 777a, 777b, 779a, 779b, 781a, 781b, 809a, 809b, 894, 1378, and 1386	97.35	2.65	.24	.77	1.00	1.77	.65
1211	51	Beef, round, lean, large piece	98.35	1.65	.14	.51	.60	1.11	.40
1205	48	.....do	98.17	1.83	.08	.56	.74	1.30	.45
1242	54	.....do	98.67	1.33	.11	.41	.47	.88	.34
895	18	.....do	97.54	2.46	.12	.74	1.01	1.75	.59
		Average	98.18	1.82	.11	.56	.71	1.26	.45
1379	66	Beef, round, lean, large piece	98.01	1.99	.11	.64	.82	1.46	.42
1027	19	.....do	97.71	2.29	.13	.86	.75	1.61	.55
1387	74	.....do	98.51	1.49	.13	.58	.42	1.00	.36
1097	19	.....do	97.84	2.16	.13	.70	.85	1.55	.48
		Average	98.02	1.98	.13	.70	.71	1.41	.45
		Average Nos. 895, 1027, 1097, 1205, 1211, 1242, 1379, and 1387	98.10	1.90	.12	.63	.71	1.34	.45
892	16	Beef, round, fat	98.24	1.76	.11	.54	.66	1.20	.45
893	16	.....do	98.27	1.73	.16	.51	.64	1.15	.42
1091	26	.....do	98.04	1.96	.10	.60	.80	1.10	.46
1092	26	.....do	98.32	1.68	.14	.50	.66	1.16	.38
1172	35	.....do	98.72	1.28	.07	.37	.54	.91	.30
		Average	98.32	1.68	.12	.50	.66	1.16	.40
1093	27	Beef, "plate boil," very fat	99.12	.88	.08	.25	.34	.59	.21
1094	27	.....do	99.27	.73	.05	.18	.34	.52	.16
		Average	99.20	.81	.07	.22	.34	.56	.19
1098	29	Beef, round, rather fat	97.64	2.36	.20	.64	1.02	1.66	.50
1099	29	.....do	98.14	1.86	.16	.51	.78	1.29	.41
1146	30	.....do	97.75	2.25	.12	.69	.93	1.62	.51
1147	30	.....do	98.19	1.81	.09	.55	.73	1.28	.44
		Average	97.93	2.07	.14	.60	.86	1.46	.47

TABLE 132.—*Composition of clear, filtered broth. (Results of experiments made in 1898–1903)*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat.	Percentage composition of the clear, filtered broth.						Ash.
			Water.	Total solid matter.	Proteid.	Organic extractives.			
						Nitrogenous.	Non-nitrogenous	Total.	
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1160	32	Beef, "plate boil," very fat	99.14	0.86	0.07	0.24	0.37	0.61	0.18
1161	32	do	98.89	1.11	.07	.31	.49	.80	.24
1162	33	Beef, neck, very fat	99.04	.96	.11	.27	.38	.65	.20
1163	33	do	99.21	.79	.10	.22	.31	.53	.16
1169	34	Beef, ribs, very fat	98.77	1.23	.12	.36	.49	.85	.26
1170	34	do	98.97	1.03	.11	.31	.39	.70	.22
		Average of above	99.00	1.00	.10	.29	.40	.69	.21
1177	38	Veal, leg	98.21	1.79	.35	.45	.64	1.09	.35
1178	38	do	98.48	1.52	.33	.39	.50	.89	.30
1181	40	do	97.98	2.02	.35	.48	.81	1.29	.38
1182	40	do	98.42	1.58	.34	.37	.57	.94	.30
		Average	98.27	1.73	.34	.42	.63	1.05	.33
1179	39	Mutton, leg	97.87	2.13	.16	.67	.84	1.51	.46
1180	39	do	98.00	2.00	.21	.58	.81	1.39	.40
1183	41	do	98.10	1.90	.12	.47	.91	1.38	.40
1184	41	do	98.28	1.72	.15	.40	.81	1.21	.36
		Average	98.06	1.94	.16	.53	.84	1.37	.41
1173	36	Pork, fresh ham	99.00	1.00	.11	.28	.39	.67	.22
1174	36	do	98.84	1.16	.06	.35	.50	.85	.25
1175	37	do	98.92	1.08	.05	.33	.43	.76	.27
1176	37	do	98.86	1.14	.05	.35	.46	.81	.28
		Average	98.90	1.10	.07	.33	.44	.77	.26
1206	48	Beef, round, lean	97.49	2.51	.09	.79	1.03	1.82	.60
1212	51	do	97.78	2.22	.17	.67	.83	1.50	.55
1243	54	do	98.12	1.88	.15	.60	.66	1.26	.47
		Average	97.80	2.20	.14	.69	.84	1.53	.54
		Average of 58 above	98.07	1.93	.15	.57	.74	1.31	.45
820a	21	Beef, round, lean	98.34	1.66	.24	.44	.61	1.05	.37
820b	24	do	97.71	2.29	.41	.57	.84	1.41	.47
		Average	98.02	1.98	.33	.51	.73	1.23	.42
1376	63	Beef, round, lean, 1 piece	97.75	2.25	.50	.56	.64	1.20	.55
1384	71	do	97.56	2.44	.45	.69	.81	1.50	.49
		Average	97.65	2.35	.48	.63	.73	1.35	.52
1377	64	Beef, round, lean, 1 piece	98.19	1.81	.33	.50	.58	1.08	.40
1385	72	do	98.60	1.40	.20	.42	.47	.89	.31
		Average	98.39	1.61	.27	.46	.53	.99	.36
1368	59	Beef, round, ½-inch cubes	97.34	2.66	.22	.84	.98	1.82	.62
1380	67	do	98.45	1.55	.18	.47	.24	.71	.66
		Average	97.89	2.11	.20	.66	.61	1.27	.64
1369	60	Beef, round, ½-inch cubes	97.82	2.18	.31	.68	.69	1.37	.50
1381	68	do	97.61	2.39	.38	.71	.83	1.54	.47
		Average	97.71	2.29	.34	.70	.76	1.46	.49
		Average Nos. 1368, 1369, 1376, 1377, 1380, 1381, 1384, and 1385	97.92	2.08	.32	.61	.65	1.26	.50

TABLE 132.—*Composition of clear, filtered broth. (Results of experiments made in 1898–1903)*—Continued.

Laboratory No.	Cooking experiment No.	Kind of meat.	Percentage composition of the clear, filtered broth.						
			Water	Total solid matter	Proteid.	Organic extractives.			Ash.
						Nitrogenous	Non-nitrogenous	Total	
			Per ct	*Per ct*	*Per ct*	*Per ct*	*Per ct*	*Per ct*	*Per ct.*
1171	35	Beef, round, lean	98.61	1.39	0.08	0.41	0.55	0.96	0.35
771a	17	.....do	97.52	2.48	.06	.79	1.06	1.85	.57
771b	17	.....do	97.46	2.54	.09	.77	1.08	1.85	.60
823a	25	.....do	97.54	2.46	.11	.78	.99	1.77	.58
823b	25	.....do	97.59	2.41	.15	.74	.97	1.71	.55
		Average Nos. 771a, 771b, 823a, and 823b	97.53	2.47	.10	.77	1.02	1.79	.58
		Average Nos 771a, 771b, 820a, 820b, 823a, 823b, 1171, 1368, 1369, 1376, 1377, 1380, 1381, 1384, and 1385	97.87	2.13	.25	.62	.75	1.38	.50
		Average of 73 above	98.03	1.97	.17	.59	.71	1.34	.46
		Maximum	99.27	2.95	.50	.95	1.18	2.08	.73
		Minimum	97.05	.73	.05	.18	.24	.52	.16

Laboratory No.	Cooking-experiment No.	Kind of meat.	Percentage composition of the clear, filtered broth. (Water-free substance.)				
			Proteid.	Organic extractives.			Ash.
				Nitrogenous.	Non-nitrogenous.	Total.	
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1158	31	Beef, round, lean	5.00	28.75	44.38	73.13	21.87
1095	28	.....do	4.67	29.18	41.64	70.82	24.51
1096	28	.....do	6.35	29.76	40.48	70.24	23.41
		Average Nos. 1095 and 1096	5.51	29.47	41.06	70.53	23.96
1370	61	Beef, round, lean, ½-inch cubes	7.19	30.22	38.13	68.35	24.46
1382	69	.....do	2.16	34.17	40.29	74.46	23.38
		Average	4.68	32.20	39.21	71.40	23.92
1371	62	Beef, round, lean, ½-inch cubes	4.26	32.56	38.76	71.32	24.42
1383	70	.....do	2.27	33.71	40.53	74.24	23.49
		Average	3.26	33.14	39.64	72.78	23.96
		Average Nos. 1370, 1371, 1382, and 1383	3.97	32.67	39.42	72.09	23.94
894	18	Beef, round, lean, small piece	4.10	30.72	40.27	70.99	24.91
779b	21	.....do	14.58	27.12	35.25	62.37	23.05
809b	23	.....do	4.46	29.74	41.64	71.38	24.16
781b	22	.....do	11.24	28.09	37.08	65.17	23.59
		Average	8.59	28.92	38.56	67.48	23.93
1378	65	Beef, round, lean, small piece	3.84	32.91	35.47	68.38	27.78
779a	21	.....do	14.71	27.21	34.19	61.40	23.90
1386	73	.....do	2.38	32.14	38.89	71.03	26.59
809a	23	.....do	5.98	29.08	40.24	69.32	24.70
781a	22	.....do	12.41	25.56	38.72	64.28	23.31
777a	20	.....do	11.24	27.31	36.95	64.26	24.50
777b	20	.....do	13.28	28.41	35.42	63.84	22.88
		Average	9.12	28.95	37.13	66.07	24.81
		Average Nos. 777a, 777b, 779a, 779b, 781a, 781b, 809a, 809b, 894, 1378, and 1386	8.93	28.94	37.65	66.58	24.49

TABLE 132.—*Composition of clear, filtered broth. (Results of experiments made in 1898–1903)*—Continued.

Laboratory No.	Cooking-experiment No.	Kind of meat.	Percentage composition of the clear, filtered broth. (Water-free substance.)				
			Proteid.	Organic extractives.			Ash.
				Nitrogenous.	Non-nitrogenous.	Total.	
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1211	51	Beef, round, lean, large piece	8.49	30.91	36.36	67.27	24.24
1205	48	do	4.37	30.60	40.44	71.04	24.59
1242	54	do	8.27	30.83	35.34	66.17	25.56
895	18	do	4.88	30.08	41.06	71.14	23.98
		Average	6.50	30.61	38.30	68.91	24.59
1379	66	Beef, round, lean, large piece	5.53	32.16	41.21	73.37	21.10
1027	19	do	5.67	37.55	32.75	70.31	24.02
1387	74	do	8.73	38.92	28.19	67.11	24.16
1097	19	do	6.02	32.41	39.35	71.76	22.22
		Average	6.49	35.26	35.38	70.64	22.88
		Average Nos. 895, 1027, 1097, 1205, 1211, 1242, 1379, and 1387	6.50	32.94	36.84	69.78	23.73
892	16	Beef, round, fat	6.25	30.68	37.50	68.18	25.57
893	16	do	9.25	29.48	36.99	66.47	24.28
1091	26	do	5.10	30.61	40.81	71.43	23.47
1092	26	do	8.33	29.76	39.28	69.05	22.62
1172	35	do	5.47	28.91	42.19	71.09	23.44
		Average	6.88	29.89	39.35	69.24	23.88
1093	27	Beef, "plate boil," very fat	9.09	28.41	38.64	67.05	23.86
1094	27	do	6.85	24.66	46.57	71.23	21.92
		Average	7.97	26.54	42.60	69.14	22.89
1098	29	Beef, round, rather fat	8.48	27.12	43.22	70.34	21.18
1099	29	do	8.60	27.42	41.94	69.36	22.04
1146	30	do	5.33	30.67	41.33	72.00	22.67
1147	30	do	4.97	30.39	40.33	70.72	24.31
		Average	6.85	28.90	41.70	70.60	22.55
1160	32	Beef, "plate boil," very fat	8.14	27.91	43.02	70.93	20.93
1161	32	do	6.31	27.93	44.14	72.07	21.62
1162	33	Beef, neck, very fat	11.46	28.13	39.58	67.71	20.83
1163	33	do	12.66	27.85	39.24	67.09	20.25
1169	34	Beef, ribs, very fat	9.75	29.27	39.84	69.11	21.14
1170	34	do	10.68	30.10	37.86	67.96	21.36
		Average of above	9.83	28.53	40.62	69.15	21.02
1177	38	Veal, leg	19.56	25.14	35.75	60.89	19.55
1178	38	do	21.71	25.66	32.89	58.55	19.74
1181	40	do	17.33	23.76	40.10	63.86	18.81
1182	40	do	21.52	23.42	36.07	59.49	18.99
		Average	20.03	24.50	36.20	60.70	19.27
1179	39	Mutton, leg	7.51	31.46	39.43	70.89	21.60
1180	39	do	10.50	29.00	40.50	69.50	20.00
1183	41	do	6.32	24.74	47.89	72.63	21.05
1184	41	do	8.72	23.26	47.09	70.35	20.93
		Average	8.26	27.11	43.73	70.84	20.90
1173	36	Pork, fresh ham	11.00	28.00	39.00	67.00	22.00
1174	36	do	5.17	30.18	43.10	73.28	21.55
1175	37	do	4.63	30.56	39.81	70.37	25.00
1176	37	do	4.39	30.70	40.35	71.05	24.56
		Average	6.30	29.86	40.56	70.42	23.28

TABLE 132.—*Composition of clear, filtered broth. (Results of experiments made in 1898–1903)*—Continued.

Laboratory No.	Cooking-experiment No.	Kind of meat.	Percentage composition of the clear, filtered broth. (Water-free substance.)				
			Proteid.	Organic extractives.			Ash.
				Nitrogenous.	Non-nitrogenous.	Total.	
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1206	48	Beef, round, lean	3.59	31.47	41.04	72.51	23.90
1212	51	.....do	7.66	30.18	37.38	67.57	24.77
1243	54	.....do	7.98	31.91	35.11	67.02	25.00
		Average	6.41	31.19	37.84	69.03	24.56
		Average of 58 above	8.21	29.46	39.34	68.79	22.99
820a	24	Beef, round, lean	14.46	26.51	36.75	63.25	22.29
820b	24	.....do	17.91	24.89	36.68	61.57	20.52
		Average	16.19	25.70	36.72	62.41	21.40
1376	63	Beef, round, lean, 1 piece	22.22	24.89	28.44	53.33	24.45
1384	71	.....do	18.44	28.28	33.20	61.48	26.08
		Average	20.33	26.58	30.82	57.40	22.27
1377	64	Beef, round, lean, 1 piece	18.23	27.62	32.05	59.67	22.10
1385	72	.....do	14.29	30.00	33.57	63.57	22.14
		Average	16.26	28.81	32.81	61.62	22.12
1368	59	Beef, round, ½-inch cubes	8.27	31.58	36.84	68.42	23.31
1380	67	.....do	11.61	30.32	15.49	45.81	42.58
		Average	9.94	30.95	26.17	57.12	32.94
1369	60	Beef, round, ½-inch cubes	14.22	31.19	31.65	62.84	22.94
1381	68	.....do	15.90	29.71	34.73	64.44	19.66
		Average	15.06	30.45	33.19	63.64	21.30
		Average Nos. 1368, 1369, 1376, 1377, 1380, 1381, 1384, and 1385	15.40	29.20	30.75	59.95	24.66
1171	35	Beef, round, lean	5.76	29.49	39.57	69.06	25.18
771a	17	.....do	2.42	31.85	42.74	74.59	22.99
771b	17	.....do	3.54	30.32	42.52	72.84	23.62
823a	25	.....do	4.47	31.71	40.24	71.95	23.58
823b	25	.....do	6.22	30.70	40.25	70.95	22.83
		Average Nos. 771a, 771b, 823a, and 823b	4.16	31.14	41.44	72.58	23.26
		Average Nos. 771a, 771b, 820a, 820b, 823a, 823b, 1171, 1368, 1369, 1376, 1377, 1380, 1381, 1384, and 1385	11.86	29.27	34.98	64.25	23.89
		Average of 73 above	8.96	29.42	38.44	67.86	23.18
		Maximum	22.22	38.92	47.89	74.59	32.94
		Minimum	2.16	23.26	15.49	57.12	18.81

TABLE 133.—*Composition of clear, filtered broth.* (*Results of experiments made in 1903–1904.*)

[Calculated to the basis, 100 grams of meat give 100 grams of broth, or 1 pound of meat gives 1.04 pints of broth.]

Cooking experiment No.	Laboratory No.	Kind of meat.	Method of cooking.			Weight of meat taken.	Weight of suspended matter in broth.	Weight of clear broth.
			Temperature.		Duration of cooking.			
			At beginning.	During cooking.				
			°*C.*	°*C.*	*Hours.*	*Grams.*	*Grams.*	*Grams.*
109	1642	Beef, round, 1-inch cubes	Cold.	85	3	1,000.00	19.79	980.21
137	1754	Beef, round, 2-inch cubes	Cold.	85	3	900.00	11.12	888.88
		Average	Cold.	85	3		15.46	934.55
139	1756	Beef, round, browned, 2-inch cubes	Cold.	85	3	900.00	6.62	893.38
		Average Nos. 1642, 1754, and 1756	Cold.	85	3		12.51	920.82
136	1746	Beef, round, browned, 2-inch cubes	85	85	3	1,000.00	17.53	982.47
145	1772	Beef, round, 2-inch cubes	85	85	3	1,074.83	5.56	1,069.27
154	1783	do	85	85	3	1,052.17		
		Average Nos. 1772 and 1783	85	85	3		11.55	1,025.87
108	1641	Beef, round, 1-inch cubes	100	85	3	1,000.00	10.37	989.63
134	1744	Beef, round, 2-inch cubes	100	85	3	1,000.00	3.70	996.30
		Average	100	85	3		7.04	992.97
144	1773	Beef, round, 1 piece	100	85	3	1,027.72	2.34	1,025.38
153	1784	do	100	85	3	1,098.31	4.44	1,093.87
		Average	100	85	3		3.39	1,059.63
		Average Nos. 1641, 1744, 1773, and 1784	100	85	3		5.21	1,026.30
138	1755	Beef, round, 2-inch cubes	Cold.	100	3	900.00	17.38	882.62
140	1757	Beef, round, browned, 2-inch cubes	Cold.	100	3	900.00	6.99	893.01
		Average	Cold.	100	3		12.19	887.82
133	1743	Beef, round, 2-inch cubes	100	100	3	1,000.00	5.03	994.97
135	1745	Beef, round, browned, 2-inch cubes	100	100	3	1,000.00	25.80	974.20
		Average	100	100	3		15.42	984.59
		Average of all cooked 3 hours			3		10.51	974.17
113	1646	Beef, round, ¾-inch cubes	Cold.	65	5	1,000.00	13.74	986.26
112	1645	do	Cold.	85	5	1,000.00	17.95	982.05
116	1654	Veal, leg, 1-inch cubes	Cold.	85	5	1,000.00	7.98	992.02
118	1658	do	Cold.	85	5	1,000.00	10.68	989.32
		Average Nos. 1654 and 1658	Cold.	85	5		9.33	990.67
		Average Nos. 1645, 1654, and 1658	Cold.	85	5		12.20	987.80
111	1644	Beef, round, ¾-inch cubes	100	85	5	1,000.00	11.94	988.06
131	1720	Beef, round, 1-inch cubes	100	85	5	1,000.00	14.03	985.97
		Average	100	85	5		12.99	987.02
121	1665	Beef, neck, ¾-inch cubes	100	85	5	700.00	8.58	691.42
123	1673	Beef, rump, 1-inch cubes	100	85	5	1,000.00	65.04	934.96
125	1703	do	100	85	5	1,000.00	24.66	975.34
		Average Nos. 1673 and 1703	100	85	5		44.85	955.15

TABLE 133.—*Composition of clear, filtered broth. (Results of experiments made in 1903–1904)*—Continued.

Cooking experiment No.	Laboratory No.	Kind of meat.	Method of cooking.			Weight of meat taken.	Weight of suspended matter in broth.	Weight of clear broth.
			Temperature.		Duration of cooking.			
			At beginning.	During cooking.				
			°C.	°C.	Hours.	Grams.	Grams.	Grams.
122	1669	Beef, flank, ¾-inch cubes	100	85	5	1,000.00	65.71	931.29
115	1653	Veal, leg, 1-inch cubes	100	85	5	1,000.00	2.93	997.07
117	1664	.....do	100	85	5	1,000.00	4.67	995.33
		Average Nos. 1653 and 1664	100	85	5	....	3.80	996.20
		Average Nos. 1644, 1653, 1661, 1665, 1669, 1673, 1703, and 1720	100	85	5	....	21.70	937.81
107	1639	Beef, round, 1-inch cubes	100	100	5	1,000.00	9.15	990.85
110	1643	Beef, round, ¾-inch cubes	100	100	5	1,000.00	10.60	989.40
132	1721	Beef, round, 1-inch cubes	100	100	5	1,000.00	12.10	987.60
		Average	100	100	5	....	10.72	989.28
126	1701	Beef, rump, 1-inch cubes	100	100	5	1,000.00	32.25	967.75
114	1652	Veal, leg, 1-inch cubes	100	100	5	1,000.00	2.07	997.93
		Average Nos. 1639, 1643, 1652, 1701, and 1721	100	100	5	....	13.29	986.71
		Average of all cooked 5 hours	....	....	5	....	18.49	963.86
		Average of all cooked 3 and 5 hours	....	....	....	....	15.03	968.33
		Maximum	....	....	....	1,098.31	65.71	1,093.87
		Minimum	....	....	....	700.00	2.07	691.42

Cooking experiment No.	Laboratory No.	Kind of meat.	Percentage composition of clear, filtered broth.						
			Water.	Total solid matter.	Proteid.	Organic extractives.			Ash.
						Nitrogenous.	Non-nitrogenous.	Total.	
			Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
109	1642	Beef, round, 1-inch cubes	96.63	3.37	0.18	1.04	1.37	2.41	0.79
137	1754	Beef, round, 2-inch cubes	97.28	2.72	.18	.87	1.07	1.94	.60
		Average	96.96	3.05	.18	.96	1.22	2.18	.70
139	1756	Beef, round, browned, 2-inch cubes	97.27	2.73	.17	.88	1.07	1.95	.61
		Average Nos. 1642, 1754, and 1756	97.06	2.94	.18	.93	1.17	2.10	.67
136	1746	Beef, round, browned, 2-inch cubes	97.20	2.80	.22	.85	1.11	1.96	.61
145	1772	Beef, round, 2-inch cubes	97.72	2.28	.17	.75	.84	1.59	.52
154	1783	.....do	....	....	....	....	....	....	....
		Average Nos. 1772 and 1783	97.46	2.54	.20	.80	.98	1.78	.57
108	1641	Beef, round, 1-inch cubes	96.57	3.43	.22	1.07	1.37	2.44	.76
134	1744	Beef, round, 2-inch cubes	97.05	2.95	.28	.87	1.19	2.06	.61
		Average	96.81	3.19	.25	.97	1.28	2.25	.69
144	1773	Beef, round, 1 piece	97.98	2.02	.15	.67	.74	1.41	.46
153	1784	.....do	97.70	2.30	.16	.74	.88	1.62	.52
		Average	97.84	2.16	.16	.71	.81	1.52	.49
		Average Nos. 1641, 1744, 1773, and 1784	97.33	2.68	.20	.84	1.05	1.89	.59

TABLE 133.—*Composition of clear, filtered broth.* (*Results of experiments made in 1903–1904*)—Continued.

Cooking experiment No.	Laboratory No.	Kind of meat.	Percentage composition of clear, filtered broth.						
			Water.	Total solid matter.	Proteid.	Organic extractives.			Ash.
						Nitrogenous.	Nonnitrogenous.	Total.	
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
138	1755	Beef, round, 2-inch cubes....	97.10	2.90	0.26	0.91	1.08	1.99	0.64
140	1757	Beef, round, browned, 2-inch cubes......................	97.12	2.88	.25	.89	1.09	1.98	.64
		Average...............	97.11	2.89	.26	.90	1.09	1.99	.64
133	1743	Beef, round, 2-inch cubes....	97.02	2.98	.35	.89	1.12	2.01	.62
135	1745	Beef, round, browned, 2-inch cubes......................	97.14	2.86	.34	.84	1.09	1.93	.58
		Average...............	97.08	2.92	.35	.86	1.11	1.97	.60
		Average of all cooked 3 hours................	97.21	2.79	.23	.87	1.08	1.95	.61
113	1646	Beef, round, ¾-inch cubes....	96.88	3.12	.24	.93	1.21	2.14	.75
112	1645	.....do......................	96.82	3.18	.15	1.01	1.29	2.30	.74
116	1654	Veal, leg, 1-inch cubes.......	97.06	2.94	.41	.76	1.15	1.91	.63
118	1658	.....do......................	97.13	2.87	.46	.80	.97	1.77	.64
		Average Nos. 1654 and 1658.................	97.10	2.91	.44	.78	1.06	1.84	.64
		Average Nos. 1645, 1654, and 1658............	97.00	3.00	.34	.86	1.11	2.00	.67
111	1644	Beef, round, ¾-inch cubes....	96.93	3.07	.22	.93	1.21	2.14	.71
131	1720	Beef, round, 1-inch cubes....	96.75	3.25	.29	.96	1.36	2.32	.64
		Average...............	96.84	3.16	.26	.94	1.29	2.23	.68
121	1665	Beef, neck, ¾-inch cubes.....	97.07	2.93	....	....	....	....	.68
123	1673	Beef, rump, 1-inch cubes....	97.56	2.44	.34	.65	.92	1.57	.53
125	1703	.....do......................	97.11	2.89	.35	.88	1.05	1.93	.61
		Average Nos. 1673 and 1703.................	97.34	2.67	.35	.76	.99	1.76	.57
122	1669	Beef, flank, ¾-inch cubes.....	97.49	2.51	.65	.60	.79	1.39	.47
115	1653	Veal, leg, 1-inch cubes	97.12	2.88	.27	.85	1.13	1.98	.63
117	1664	.....do......................	97.18	2.82	.50	.78	.92	1.70	.62
		Average Nos. 1653 and 1664.................	97.15	2.85	.39	.81	1.03	1.84	.63
		Average Nos. 1644, 1653, 1664. 1665, 1669, 1673, 1703, and 1720...	97.15	2.85	.38	.81	1.05	1.86	.61
107	1639	Beef, round, 1-inch cubes....	96.83	3.17	.34	.89	1.26	2.15	.67
110	1643	Beef, round, ¾-inch cubes....	96.96	3.04	.41	.89	1.10	1.99	.61
132	1721	Beef, round, 1-inch cubes....	96.61	3.39	.61	.89	1.29	2.18	.60
		Average...............	96.80	3.20	.45	.89	1.22	2.11	.64
126	1704	Beef, rump, 1-inch cubes....	96.81	3.19	.90	.77	.97	1.74	.51
114	1652	Veal, leg, 1-inch cubes.......	97.32	2.68	.55	.67	.96	1.63	.51
		Average Nos. 1639, 1643, 1652, 1704, and 1721...	96.91	3.09	.56	.82	1.12	1.94	.59
		Average of all cooked 5 hours..............	97.04	2.96	.42	.83	1.10	1.93	.62
		Average of all cooked 3 and 5 hours..........	97.11	2.89	.33	.85	1.09	1.94	.62
		Maximum.............	97.98	3.43	.96	1.07	1.37	2.44	.79
		Minimum..............	96.57	2.02	.15	.60	.74	1.39	.46

TABLE 133.—*Composition of clear, filtered broth. (Results of experiments made in 1903–1904)*—Continued.

Cooking experiment No.	Laboratory No.	Kind of meat.	Percentage composition of the clear, filtered broth. (Water-free substance.)				
			Proteid.	Organic extractives.			Ash.
				Nitrogenous.	Non-nitrogenous.	Total.	
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
109	1642	Beef, round, 1-inch cubes	5.34	30.86	40.65	71.51	23.44
137	1754	Beef, round, 2-inch cubes	6.62	31.99	39.34	71.32	22.06
		Average	5.98	31.43	40.00	71.42	22.75
139	1756	Beef, round, browned, 2-inch cubes.	6.23	32.23	39.19	71.43	22.35
		Average Nos. 1642, 1754, 1756.	6.06	31.69	39.73	71.42	22.62
136	1746	Beef, round, browned, 2-inch cubes.	7.86	30.36	39.64	70.00	21.79
145	1772	Beef, round, 2-inch cubes	7.15	32.89	36.84	69.74	22.81
151	1783	.....do	....	....	....	....	....
		Average Nos. 1772 and 1783	7.66	31.63	38.24	69.87	22.30
108	1641	Beef, round, 1-inch cubes	6.41	31.20	39.94	71.11	22.16
134	1744	Beef, round, 2-inch cubes	9.49	29.49	40.34	69.83	20.68
		Average	7.95	30.35	40.14	70.49	21.42
144	1773	Beef, round, 1 piece	7.43	33.17	36.63	69.80	22.77
153	1784	.....do	6.96	32.17	38.26	70.43	22.61
		Average	7.20	32.67	37.45	70.12	22.69
		Average Nos. 1641, 1741, 1773, and 1781	7.57	31.51	38.79	70.30	22.06
138	1755	Beef, round, 2-inch cubes	8.97	31.38	37.21	68.62	22.07
140	1757	Beef, round, browned, 2-inch cubes.	8.68	30.90	37.85	68.75	22.22
		Average	8.82	31.14	37.55	68.69	22.15
133	1743	Beef, round, 2-inch cubes	11.74	29.87	37.58	67.45	20.80
135	1745	Beef, round, browned, 2-inch cubes.	11.89	29.37	38.11	67.48	20.28
		Average	11.82	29.62	37.85	67.47	20.54
		Average of all cooked 3 hours.	8.08	31.22	38.59	69.81	22.00
113	1646	Beef, round, ¾-inch cubes	7.69	29.81	38.78	68.59	24.04
112	1645	.....do	4.72	31.76	40.57	72.33	23.27
116	1654	Veal, leg, 1-inch cubes	13.95	25.85	39.12	64.97	21.43
118	1658	.....do	16.03	27.87	33.80	61.67	22.30
		Average Nos. 1654 and 1658	14.99	26.86	36.46	63.32	21.87
		Average Nos. 1645, 1654, and 1658	11.57	28.49	37.83	66.32	22.33
111	1644	Beef, round, ¾-inch cubes	7.17	30.29	39.41	69.71	23.13
131	1720	Beef, round, 1-inch cubes	8.92	29.54	41.85	71.38	19.69
		Average	8.05	29.92	40.63	70.55	21.41
121	1665	Beef, neck, ¾-inch cubes	....	....	....	....	23.21
123	1673	Beef, rump, 1-inch cubes	13.93	26.64	37.70	64.34	21.72
125	1703	.....do	12.11	30.45	36.33	66.78	21.11
		Average Nos. 1673 and 1703	13.02	28.55	37.02	65.56	21.42
122	1669	Beef, flank, ¾-inch cubes	25.90	23.91	31.47	55.37	18.73
115	1653	Veal, leg, 1-inch cubes	9.38	29.51	39.24	68.75	21.88
117	1664	.....do	17.73	27.66	32.63	60.29	21.99
		Average Nos. 1653 and 1664	13.56	28.59	35.94	64.52	21.94
		Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	13.59	28.29	36.95	65.23	21.44

TABLE 133.—*Composition of clear, filtered broth. (Results of experiments made in 1903–1904)*—Continued.

Cooking experiment No.	Laboratory No.	Kind of meat.	Percentage composition of the clear, filtered broth. (Water-free substance.)				
			Proteid.	Organic extractives.			Ash.
				Nitrogenous.	Non-nitrogenous.	Total.	
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
107	1639	Beef, round, 1-inch cubes	10.73	28.07	39.75	67.82	21.14
110	1643	Beef, round, ¾-inch cubes	13.49	29.28	36.18	65.46	21.05
132	1721	Beef, round, 1-inch cubes	17.99	26.25	38.05	64.30	17.70
		Average	11.07	27.87	37.99	65.86	19.96
126	1704	Beef, rump, 1-inch cubes	28.21	24.14	30.41	54.55	16.93
114	1652	Veal, leg, 1-inch cubes	20.52	25.00	35.82	60.82	19.03
		Average Nos. 1639, 1643, 1652, 1704, and 1721	18.19	26.55	36.04	62.59	19.17
		Average of all cooked 5 hours	14.28	27.88	36.95	64.82	21.08
		Average of all cooked 3 and 5 hours	11.50	29.38	37.68	67.06	21.48
		Maximum	28.21	33.17	41.85	72.33	24.04
		Minimum	4.72	23.91	30.41	54.55	16.93

By referring to Table 132, page 207, it will be seen that on an average the 73 samples of clear, filtered meat broths, when calculated on the basis of 100 grams of meat per 100 grams of broth, or 1 pound of meat per 1.04 pints of complete broth, had the following percentage composition: Water 98.03, total solid matter 1.97, proteid 0.17, nitrogenous extractives 0.59, nonnitrogenous extractives 0.74, total organic extractives 1.34, fat 0.0, and ash 0.46 per cent.

Comparing the data here given for the clear, filtered broths with the results obtained for the complete broths, it is evident that the former contain much less total solid matter than the latter. The total dry substance in the clear, filtered broths varied from 0.73 to 2.95 per cent, the average being 1.97 per cent, while the total solid material in the complete broths ranged from 1.12 per cent to 10.27 per cent, averaging 3.36 per cent. In other words, the inorganic and organic material dissolved in the clear, filtered broths is equal upon the average to 59 per cent of the total solid matter of the complete broths.

The smallest quantity of solid matter, 0.73 per cent, was found in sample No. 1094, from cooking experiment No. 27, in which a large piece of very fat beef, known as "plate boil," was cooked at 100° C. for ten minutes and then at 80 to 85° C. for two hours. It was composed of 0.05 per cent proteid, 0.18 per cent nitrogenous extractives, 0.34 per cent nonnitrogenous extractives, 0.52 per cent total organic extractives, and 0.16 per cent ash, or, on a water-free basis, 6.85 per cent proteid, 24.66 per cent nitrogenous extractives, 46.57 per cent nonnitrogenous extractives, 71.23 per cent total organic extractives, and 21.92 per cent ash.

The largest quantity of solid matter, 2.95 per cent, in the clear broths was noted in sample No. 779b, from cooking experiment No. 21, in which a small piece of lean beef round was cooked at 100° C. for ten minutes and then at 80 to 85° C. for two hours. It consisted of 0.43 per cent proteid, 0.80 per cent nitrogenous extractives, 1.04 per cent nonnitrogenous extractives, 1.84 per cent total organic extractives, and 0.68 per cent ash, or, on a water-free basis, 14.58 per cent proteid, 27.12 per cent nitrogenous extractives, 35.25 per cent nonnitrogenous extractives, 62.37 per cent total organic extractives, and 23.05 per cent ash.

In discussing (see p. 200) the composition of the complete broths it was stated that the richness of the broths, as measured by the total solids which they contain, seems to depend largely upon the sizes of the pieces of meat used, and in order to show that this conclusion was justified the average results of the analyses of several series of complete broths were considered. It will be of interest to study the results obtained in the analysis of the clear, filtered broths from the same series of experiments to see whether or not they lead to the same conclusion.

The average amount of solid matter in four clear filtered broths (Nos. 1370, 1371, 1382, and 1383) prepared from lean beef round, cut into one-half inch cubes, cooked for ten minutes at 100° C., and then for two hours at 80 to 85° C., was equal to 2.70 per cent of the weight of the meat taken, and was made up of 0.11 per cent of proteid, 0.88 per cent of nitrogenous extractives, 1.06 per cent of nonnitrogenous extractives, 1.94 per cent of total organic extractives, and 0.65 per cent of ash, or, on a water-free basis, 3.97 per cent proteid, 32.67 per cent nitrogenous extractives, 39.42 per cent nonnitrogenous extractives, 72.09 per cent total organic extractives, and 23.94 per cent ash.

The average quantity of total solid material in eleven clear broths which were made by cooking small pieces of lean beef round (about 1.5 pounds) for ten minutes at 100° C. and then for two hours at 80 to 85° C. was equal to 2.65 per cent of the weight of the original complete broth. The solid constituents of these eleven clear broths consisted of 0.24 per cent proteid, 0.77 per cent nitrogenous extractives, 1.00 per cent nonnitrogenous extractives, 1.77 per cent total organic extractives, and 0.64 per cent ash, or, on a water-free basis, 8.93 per cent proteid, 28.94 per cent nitrogenous extractives, 37.65 per cent nonnitrogenous extractives, 66.58 per cent total organic extractives, and 24.49 per cent ash.

The average amount of total solid material in eight clear broths, Nos. 895, 1027, 1097, 1205, 1211, 1242, 1379, and 1387, prepared by cooking a large piece of lean beef round (about 4.5 pounds) for ten minutes at 100° C. and then for two hours at 80 to 85° C. was equal to 1.90 per cent of the weight of the entire broths, and was made up of 0.12 per cent of proteid, 0.63 per cent of nitrogenous extractives, 0.71 per cent of nonnitrogenous extractives, 1.34 per cent of total organic extractives, and 0.45 per cent ash, or, on a water-free basis, 6.50 per cent proteid, 32.94 per cent nitrogenous extractives, 36.84 per cent nonnitrogenous extractives, 69.78 per cent total organic extractives, and 23.73 per cent ash.

It is evident from these data and those on page 200 that the size of the piece of meat cooked in hot water influences the composition of the complete broth more than it does the clear broth. In other words, there are decidedly greater differences in the amounts of total solids in the complete broths than in the case of the clear broths, the difference being due mainly to variations in proteid and fat. That is to say, when meats cut into small cubes are cooked in hot water, more fat and coagulated proteid pass into the broth in insoluble form than is the case when the meats are cooked in single or large pieces. There is also a slightly greater quantity of organic extractives and ash in the broths in the former case than in the latter.

Table 132, pages 207–209, gives the chemical composition of the total solid matter contained in these clear meat broths. On a water-free basis the average values for 73 samples were: Proteid, 8.96 per cent; nitrogenous extractives, 29.42 per cent; nonnitrogenous extractives, 38.44 per cent; total organic extractives, 67.86 per cent, and ash, 23.18 per cent. The corresponding data for the same complete broths were as follows: Proteid, 11.54 per cent; nitrogenous extractives, 19.51 per cent; nonnitrogenous extractives, 24.91 per cent; total organic extractives, 44.42 per cent; fat, 28.68 per cent, and ash 15.38 per cent. The solid residues obtained from the clear broths differ from those obtained from the complete broths, in that they contain no fat, and it follows that the proportions of the other constituents, especially organic extractives and ash, are higher.

Although complete meat broths do not actually contain much real nutritive material, namely, proteid and fat, they do contain considerably more of these nutrients than the clear broths. In other words, the process of clarifying (filtering or straining) broths removes a considerable proportion of the true nutritive material present and does not alter the amount of the less valuable constituents.

As regards flavor, it is evident that since the amount of total extractives is not materially reduced, there will be little difference in flavor between complete and clear, filtered broths provided the fat content in both cases is the same.

In the experiments here considered, however, the complete broths contained considerable fat, which was removed in the process of filtration. Since it is well known that meat fat possesses a fairly distinctive flavor, its removal would tend to modify the flavor of the broth to a greater or less degree. The same conditions would also obtain in the household. If the complete broth contained but little fat, its flavor would be largely due to the extractives, and, consequently, little modified by straining. So, too, if the broths were filtered so that the fat was melted, and so passed through the strainer, but little change of flavor would be expected. On the other hand, if the original fat content was relatively large, and the fat practically all removed by the filtration, the flavor would doubtless be modified accordingly. When the data in Table 133 regarding the clear, filtered broth from small pieces of meat cooked for fairly long periods are considered, it will be seen that, taken either individually or as a whole, the results are noticeably higher—that is, the broths are richer than those obtained from meats cooked in large pieces for short periods.

The average percentage composition of 14 clear broths prepared by cooking meats for three hours was: Water 97.21, total solid matter 2.79, proteid 0.23, nitrogenous extractives 0.87, nonnitrogenous extractives 1.08, total organic extractives 1.95, and ash 0.61 per cent. The average percentage composition of 17 clear broths from meats cooked for five hours was: Water 97.04, total solid matter 2.96, proteid 0.42, nitrogenous extractives 0.83, nonnitrogenous extractives, 1.10; total organic extractives, 1.93, and ash 0.62. The more extended boiling perceptibly increased the proteid content of the broths, though the differences are less marked than in the case of the complete broths.

The differences pointed out may also be noted when the data are considered on a water-free basis. (See Table 133.)

NITROGENOUS CONSTITUENTS OF BROTHS.

Since the available information regarding the nature of the proteid and nonproteid substances occurring in meats is not very considerable, it necessarily follows that the character of these constituents in broth is also not very well understood. In view of this fact it seemed desirable to undertake at least a preliminary study of these substances as they occur in broths in connection with the similar studies of raw and cooked meats.[a]

The details of the methods used have already been described, pages 13–15. The results obtained are given in a condensed form in Tables 134 to 136, inclusive.

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[a] See this bulletin, pp. 141–169. See also Jour. Amer. Chem. Soc., 26 (1904), p. 1086, and U. S. Dept. Agr., Bureau of Chemistry Bul. 81, p. 110. See also summary on p. 229.

TABLE 134.—*Nitrogen records of the clear, filtered broth (expressed in percentage of meat taken for cooking).*

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Total nitrogen in meat.	Total nitrogen, in broth.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$.
				At beginning.	During cooking.							
				°C.	°C.	*Hrs.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1642	1640	109	Beef, round............	Cold.	85	3	5.770	0.3550	0.0008	0.0271	0.0279	....
1754	1753	137	.....do..................	Cold.	85	3	5.884	.3038	0	.0277	.0277	....
			Average..........	Cold.	85	3	5.827	.3294	.0004	.0274	.0278	....
1756	1753	139	Beef, round (browned).	Cold.	85	3	5.495	.3064	0	.0273	.0273	....
			Average Nos. 1642, 1754, and 1756..	Cold.	85	3	5.716	.3217	.0003	.0274	.0276	....
1746	1741	136	Beef, round (browned).	85	85	3	5.696	.3017	.0008	.0333	.0341	....
1769	1764	145	Beef, round............	85	85	3	5.810	.2671	.0021	.0244	.0265	....
1780	1775	154	.....do..................	85	85	3	6.040	.2547	.0038	.0163	.0201	....
			Average Nos. 1769 and 1780........	85	85	3	5.925	.2609	.0030	.0204	.0233	....
			Average Nos. 1746, 1769, and 1780..	85	85	3	5.849	.2745	.0022	.0247	.0269	....
1641	1640	108	Beef, round............	100	85	3	5.910	.3758	0	.0349	.0349	....
1744	1741	134	.....do..................	100	85	3	5.862	.3224	.0006	.0437	.0443	....
1768	1764	144	.....do..................	100	85	3	5.309	.2388	.0027	.0206	.0233	....
1779	1775	153	.....do..................	100	85	3	6.013	.2613	.0055	.0204	.0259	....
			Average..........	100	85	3	5.774	.2996	.0022	.0299	.0321	....
1755	1753	138	Beef, round............	Cold.	100	3	5.857	.3267	0	.0415	.0415	....
1757	1753	140	Beef, round (browned).	Cold.	100	3	5.855	.3253	0	.0393	.0393	....
			Average..........	Cold.	100	3	5.856	.3260	0	.0404	.0404	....
1743	1741	133	Beef, round............	100	100	3	5.834	.3403	.0012	.0548	.0560	....
1745	1741	135	Beef, round (browned).	100	100	3	5.556	.3156	.0006	.0523	.0529	....
			Average..........	100	100	3	5.695	.3280	.0009	.0536	.0545	....
			Average of all cooked 3 hours.	......	.....	3	5.785	.3068	.0013	.0331	.0344	....
1646	1647	113	Beef, round............	Cold.	65	5	5.240	.3312	.0116	.0225	.0341	0.0030
1645	1647	112	.....do..................	Cold.	85	5	5.420	.3410	.0011	.0198	.0209	.0025
1654	1656	116	Veal, leg................	Cold.	85	5	5.070	.3072	.0018	.0498	.0516	.0132
1658	1662	118	.....do..................	Cold.	85	5	4.800	.3260	.0017	.0685	.0702	.0023
			Average Nos. 1654 and 1658........	Cold.	85	5	4.935	.3166	.0018	.0592	.0609	.0078
			Average Nos. 1645, 1654, and 1658..	Cold.	85	5	5.097	.3247	.0015	.0460	.0476	.0060
1644	1647	111	Beef, round............	100	85	5	5.590	.3289	.0015	.0319	.0334	.0018
1720	1722	131	.....do..................	100	85	5	5.309	.3500	0	.0460	.0460	....
			Average..........	100	85	5	5.450	.3395	.0008	.0390	.0397	.0018
1665	1668	121	Beef, neck...............	100	85	5	5.039	.2238	.0024	....	....	.0028
1673	1676	123	Beef, rump..............	100	85	5	3.245	.2453	.0008	.0490	.0498	.0017
1703	1705	125	.....do..................	100	85	5	4.433	.3307	.0040	.0501	.0541	....
			Average Nos. 1673 and 1703........	100	85	5	3.839	.2880	.0024	.0496	.0520	.0017

Table 134.—*Nitrogen records of the clear, filtered broth (expressed in percentage of meat taken for cooking)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Total nitrogen in meat.	Total nitrogen in broth.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$.
				At beginning.	During cooking.							
				°C.	°C.	Hrs.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1669	1672	122	Beef, flank	100	85	5	3.210	0.2777	0.0019	0.0942	0.0961	0.0018
1653	1656	115	Veal, leg	100	85	5	5.360	.3152	.0044	.0230	.0274	.0155
1664	1662	117	do	100	85	5	4.900	.3292	.0017	.0754	.0771	.0029
			Average Nos. 1653 and 1664	100	85	5	5.130	.3222	.0031	.0492	.0523	.0092
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	100	85	5	4.636	.3001	.0021	.0528	.0548	.0044
1639	1637	107	Beef, round	100	100	5	5.640	.3392	.0017	.0530	.0547	......
1643	1647	110	do	100	100	5	5.370	.3458	.0035	.0590	.0625	.0030
1721	1722	132	do	100	100	5	5.324	.3785	0	.0962	.0962	......
			Average	100	100	5	5.445	.3545	.0017	.0694	.0711	.0030
1704	1705	126	Beef, rump	100	100	5	4.583	.3787	.0035	.1364	.1399	......
1652	1656	114	Veal, leg	100	100	5	5.310	.3013	.0017	.0706	.0723	.0148
			Average Nos. 1639, 1643, 1652, 1704, and 1721	100	100	5	5.246	.3487	.0021	.0830	.0851	.0089
			Average of all cooked 5 hours	......	......	5	4.932	.3206	.0026	.0591	.0616	.0054
			Average of all cooked 3 or 5 hours	......	......	......	5.317	.3144	.0020	[a].0470	[a].0489	[b].0054

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Proteid nitrogen in broth.	Nonproteid nitrogen in broth.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen precipitated by alcohol.	Nitrogen as ammonia.
				P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
1642	1640	109	Beef, round	0.0279	0.3271	......	......	0.0272	0.1144	......	......	......
1754	1753	137	do	.0277	.2761	......	0.0300	.0284	.0370	0.0511	......	0.0137
			Average	.0278	.3016	......	.0300	.0278	.0757	.0511	......	.0137
1756	1753	139	Beef, round (browned)	.0273	.2791	......	.0285	.0278	.0352	.0479	......	.0135
			Average Nos. 1642, 1754, and 1756	.0276	.2941	......	.0293	.0278	.0622	.0495	......	.0136
1746	1741	136	Beef, round (browned)	.0341	.2676	......	.0282	.0318	.0339	.0167	......	.0117
1769	1764	145	Beef, round	.0265	.2406	......	.0215	.0281	.0297	.0357	......	.0115
1780	1775	154	do	.0201	.2346	......	.0226	.0127	.0201	.0362	......	.0126
			Average Nos. 1769 and 1780	.0233	.2376	......	.0221	.0204	.0249	.0360	......	.0121
			Average Nos. 1746, 1769, and 1780	.0269	.2476	......	.0241	.0242	.0279	.0295	......	.0119
1641	1640	108	Beef round	.0349	.3409	......	......	.0390	.1251	......	......	......
1744	1741	134	do	.0443	.2781	......	.0349	.0390	.0553	.0181	......	.0129
1768	1764	144	do	.0233	.2155	......	.0189	.0200	.0272	.0330	......	.0094
1779	1775	153	do	.0259	.2354	......	.0234	.0110	.0202	.0338	......	.0097
			Average	.0321	.2675	......	.0257	.0273	.0570	.0283	......	.0107

[a] Average of 30 analyses.

[b] Average of 12 analyses.

TABLE 134.—*Nitrogen records of the clear, filtered broth (expressed in percentage of meat taken for cooking)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Proteid nitrogen in broth.	Nonproteid nitrogen in broth.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen precipitated by alcohol.	Nitrogen as ammonia.
				P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1755	1753	138	Beef, round	0.0415	0.2852	......	0.0425	0.0421	0.0426	0.0532	......	0.0181
1757	1753	140	Beef, round (browned)	.0393	.2860	......	.0364	.0315	.0403	.0482	......	.0176
			Average	.0404	.2856	......	.0395	.0368	.0415	.0507	......	.0179
1743	1741	133	Beef, round	.0560	.2843	......	.0276	.0879	.0266	.0238	......	.0156
1745	1741	135	Beef, round (browned)	.0529	.2627	......	.0309	.0540	.0545	.0278	......	.0159
			Average	.0545	.2735	......	.0293	.0710	.0406	.0258	......	.0158
			Average of all cooked 3 hours	.0344	.2724	......	.0288	.0343	.0473	.0355	......	.0135
1646	1647	113	Beef, round	.0371	.2941	......	......	.0385	.0437	......	......	.0024
1645	1647	112	do	.0234	.3176	......	......	.0360	.0385	......	......	.0043
1654	1656	116	Veal, leg	.0648	.2424	0.0312	.0196	.0366	.0353	......	......	.0121
1658	1662	118	do	.0725	.2535	.0674	.0246	.0822	.0668	......	......	.0142
			Average Nos. 1654 and 1658	.0687	.2480	.0493	.0221	.0594	.0511	......	......	.0132
			Average Nos. 1645, 1654, and 1658	.0536	.2712	.0493	.0221	.0516	.0469	......	......	.0102
1644	1647	111	Beef, round	.0352	.2937	......	......	.0355	.0612	......	......	.0061
1720	1722	131	do	.0460	.3040	......	.0483	.0477	.0540	.0434	0.1149	.0117
			Average	.0406	.2989	......	.0483	.0416	.0576	......	......	.0089
1665	1668	121	Beef, neck	......	......	.0248	.0186	.0301	.0395	......	......	.0185
1673	1676	123	Beef, rump	.0515	.1938	.0706	.0410	.0291	.0338	......	......	.0135
1703	1705	125	do	.0541	.2766	......	.0574	.0519	.0589	.0327	.0926	.0197
			Average Nos. 1673 and 1703	.0528	.2352	.0706	.0492	.0405	.0464	......	......	.0166
1669	1672	122	Beef, flank	.0979	.1798	.0803	.0436	.1019	.0912	......	......	.0195
1653	1656	115	Veal, leg	.0429	.2723	.0182	.0127	.0203	.0454	......	......	.0143
1664	1662	117	do	.0800	.2492	.0661	.0246	.0828	.0716	......	......	.0140
			Average Nos. 1653 and 1664	.0615	.2608	.0422	.0187	.0516	.0585	......	......	.0142
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	.0582	.2528	.0520	.0352	.0499	.0570	......	......	.0147
1639	1637	107	Beef, round	.0547	.2845	......	......	.0799	.1765	......	......	......
1643	1647	110	do	.0655	.2803	......	......	.0725	.0950	......	......	.0073
1721	1722	132	do	.0962	.2823	......	.0749	.0924	.0928	.0441	.1624	.0177
			Average	.0721	.2824	......	.0749	.0816	.1214	......	......	.0125
1704	1705	126	Beef, rump	.1399	.2388	......	.0875	.1372	.1218	.0673	.1812	.0195
1652	1656	114	Veal, leg	.0871	.2142	.0513	.0391	.0702	.0765	......	......	.0137
			Average Nos. 1639, 1643, 1652, 1704, and 1721	.0887	.2600	.0513	.0672	.0904	.1125	......	......	.0146
			Average of all cooked 5 hours	.0656	.2611	.0512	.0410	.0614	.0708	......	......	.0131
			Average of all cooked 3 or 5 hours	[a].0510	[a].2664	[b].0512	[c].0349	.0492	.0602	[d].0384	[e].1378	[f].0133

[a] Average of 30 analyses.
[b] Average of 8 analyses.
[c] Average of 13 analyses.
[d] Average of 16 analyses.
[e] Average of 4 analyses.
[f] Average of 29 analyses.

Table 135.—*Nitrogen records of the clear, filtered broth (expressed in percentage of total nitrogen in uncooked meat).*

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Total nitrogen in uncooked meat.	Total nitrogen in broth.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$.
				At beginning.	During cooking.							
				°*C.*	°*C.*	*Hrs.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1642	1640	109	Beef, round............	Cold.	85	3	100	9.92	0.02	0.76	0.78	....
1754	1753	137	.....do.................	Cold.	85	3	100	8.85	0	.81	.81	....
			Average.........	Cold.	85	3	100	9.39	.01	.79	.80	.....
1756	1753	139	Beef, round (browned).	Cold.	85	3	100	8.93	0	.80	.80	....
			Average Nos. 1642, 1754, and 1756 ..	Cold.	85	3	100	9.23	.01	.79	.80	.....
1746	1741	136	Beef, round (browned).	85	85	3	100	8.81	.02	.97	1.00	....
1769	1764	145	Beef, round............	85	85	3	100	8.22	.06	.75	.82	....
1780	1775	154	.....do...	85	85	3	100	7.61	.11	.49	.60	....
			Average Nos. 1769 and 1780.......	85	85	3	100	7.92	.09	.62	.71	....
			Average Nos. 1746, 1769, and 1780...	85	85	3	100	8.21	.06	.74	.81	......
1641	1640	108	Beef, round............	100	85	3	100	10.50	0	.97	.97	......
1744	1741	134	.....do.................	100	85	3	100	9.42	.02	1.28	1.29	....
1768	1764	144	.....do.................	100	85	3	100	7.35	.08	.63	.72	....
1779	1775	153	.....do.................	100	85	3	100	7.80	.16	.61	.77	....
			Average.........	100	85	3	100	8.77	.07	.87	.94	....
1755	1753	138	Beef, round............	Cold.	100	3	100	9.52	0	1.21	1.21	....
1757	1753	140	Beef, round (browned).	Cold.	100	3	100	9.47	0	1.14	1.14	....
			Average.........	Cold.	100	3	100	9.50	0	1.18	1.18	....
1743	1741	133	Beef, round............	100	100	3	100	9.94	.04	1.60	1.64	....
1745	1741	135	Beef, round (browned).	100	100	3	100	9.22	.02	1.53	1.55	....
			Average.........	100	100	3	100	9.58	.03	1.57	1.60	....
			Average of all cooked 3 hours.	......	......	......	......	8.97	.04	.97	1.01	....
1646	1647	113	Beef, round............	Cold.	65	5	100	9.89	.35	.67	1.02	0.09
1645	1647	112	.....do.................	Cold.	85	5	100	10.18	.03	.59	.62	.07
1654	1656	116	Veal, leg..............	Cold.	85	5	100	8.85	.05	1.44	1.49	.38
1658	1662	118	.....do.................	Cold.	85	5	100	10.09	.05	2.12	2.17	.07
			Average Nos. 1654 and 1658.......	Cold.	85	5	100	9.47	.05	1.78	1.83	.23
			Average Nos. 1645, 1654, and 1658...	Cold.	85	5	100	9.71	.04	1.38	1.43	.17
1644	1647	111	Beef, round............	100	85	5	100	9.82	.04	.95	1.00	.05
1720	1722	131	.....do.................	100	85	5	100	10.32	0	1.36	1.36	....
			Average.........	100	85	5	100	10.07	.02	1.16	1.18	....
1665	1668	121	Beef, neck.............	100	85	5	100	7.22	.08	....	....	.09
1673	1676	123	Beef, rump............	100	85	5	100	10.22	.03	2.04	2.08	.07
1703	1705	125	.....do.................	100	85	5	100	11.67	.14	1.77	1.91	....
			Average Nos. 1673 and 1703.......	100	85	5	100	10.95	.09	1.91	2.00	....

Table 135.—*Nitrogen records of the clear, filtered broth (expressed in percentage of total nitrogen in uncooked meat)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Total nitrogen in uncooked meat.	Total nitrogen in broth.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$.
				At beginning.	During cooking.							
				°C.	*°C.*	*Hrs.*	*P. ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1669	1672	122	Beef, flank	100	85	5	100	11.20	0.08	3.80	3.88	0.07
1653	1656	115	Veal, leg	100	85	5	100	9.08	.13	.66	.79	.45
1664	1662	117	....do	100	85	5	100	10.19	.05	2.33	2.39	.09
			Average Nos. 1653 and 1664	100	85	5	100	9.64	.09	1.50	1.59	.27
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	100	85	5	100	9.97	.07	1.85	1.92	......
1639	1637	107	Beef, round	100	100	5	100	10.01	.05	1.56	1.61	......
1643	1647	110	....do	100	100	5	100	10.32	.10	1.76	1.87	.09
1721	1722	132	....do	100	100	5	100	11.16	0	2.84	2.84	......
			Average	100	100	5	100	10.50	.05	2.05	2.11	......
1704	1705	126	Beef, rump	100	100	5	100	13.36	.12	4.81	4.93	......
1652	1656	114	Veal, leg	100	100	5	100	8.68	.05	2.03	2.08	.43
			Average Nos. 1639, 1643, 1652, 1704, and 1721	100	100	5	100	10.71	.06	2.60	2.67	......
			Average of all cooked 5 hours	......	......	......	100	10.14	.08	1.92	2.01	[a].16
			Average of all cooked 3 or 5 hours	......	......	......	100	9.61	.06	1.48	[b]1.54	......

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Proteid nitrogen in broth.	Nonproteid nitrogen in broth.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen precipitated by alcohol.	Nitrogen as ammonia.
				P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1642	1640	109	Beef, round	0.78	9.14	......	......	0.76	3.20	......	......	......
1754	1753	137	....do	.81	8.04	......	0.87	.83	1.08	1.49	......	0.40
			Average	.80	8.59	......	......	.80	2.14	......	......	......
1756	1753	139	Beef, round (browned)	.80	8.13	......	.83	.81	1.03	1.40	......	.39
			Average Nos. 1642, 1754, and 1756	.80	8.44	......	.85	.80	1.77	1.45	......	.40
1746	1741	136	Beef, round (browned)	1.00	7.81	......	.82	.93	.99	.49	......	.34
1769	1764	145	Beef, round	.82	7.40	......	.66	.86	.91	1.10	......	.35
1780	1775	154	....do	.60	7.01	......	.67	.38	.60	1.08	......	.38
			Average Nos. 1769 and 1780	.71	7.21	......	.67	.62	.76	1.09	......	.37
			Average Nos. 1746, 1769, and 1780	.81	7.41	......	.72	.72	.83	.89	......	.36
1641	1640	108	Beef, round	.97	9.52	......	......	1.09	3.49	......	......	......
1744	1741	134	....do	1.29	8.12	......	1.02	1.14	1.62	.53	......	.38
1768	1764	144	....do	.72	6.63	......	.58	.62	.84	1.02	......	.29
1779	1775	153	....do	.77	7.03	......	.70	.33	.60	1.01	......	.29
			Average	.94	7.83	......	.77	.80	1.64	.85	......	.32

[b] Average of 12 analyses.

[a] Average of 30 analyses.

TABLE 135.—*Nitrogen records of the clear, filtered broth (expressed in percentage of total nitrogen in uncooked meat)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Proteid nitrogen in broth.	Nonproteid nitrogen in broth.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen precipitated by alcohol.	Nitrogen as ammonia.
				P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1755	1753	138	Beef, round	1.21	8.31	......	1.24	1.23	1.24	1.55	......	0.53
1757	1753	140	Beef, round (browned)	1.14	8.33	......	1.06	.92	1.17	1.40	......	.51
			Average	1.18	8.32	......	1.15	1.08	1.21	1.48	......	.52
1743	1741	133	Beef, round	1.64	8.30	......	.81	2.57	.78	.69	......	.46
1745	1741	135	Beef, round (browned)	1.55	7.67	......	.90	1.58	1.59	.82	......	.47
			Average	1.60	7.99	......	.86	2.08	1.19	.76	......	.47
			Average of all cooked 3 hours	1.01	7.97	......	.85	1.01	1.37	1.08	......	.40
1646	1647	113	Beef, round	1.11	8.78	......	......	1.15	1.30	......	......	.07
1645	1647	112	do	.70	9.48	......	......	1.07	1.15	......	......	.13
1654	1656	116	Veal, leg	1.87	6.98	0.90	.56	1.05	1.02	......	......	.35
1658	1662	118	do	2.24	7.85	2.09	.76	2.54	2.07	......	......	.44
			Average Nos. 1654 and 1658	2.06	7.42	1.50	.66	1.80	1.55	......	......	.40
			Average Nos. 1645, 1654, and 1658	1.60	8.10	......	......	1.55	1.41	......	......	.31
1644	1647	111	Beef, round	1.05	8.77	......	......	1.06	1.83	......	......	.18
1720	1722	131	do	1.36	8.96	......	1.42	1.41	1.59	1.28	3.39	.34
			Average	1.21	8.87	......	......	1.24	1.71	......	......	.26
1665	1668	121	Beef, neck	......	......	.80	.60	.97	1.28	......	......	.60
1673	1676	123	Beef, rump	2.15	8.07	2.94	1.71	1.21	1.41	......	......	.56
1703	1705	125	do	1.91	9.76	......	2.02	1.83	2.08	1.15	3.27	.69
			Average Nos. 1673 and 1703	2.03	8.92	......	1.87	1.52	1.75	......	......	.63
1669	1672	122	Beef, flank	3.95	7.25	3.24	1.76	4.11	3.68	......	......	.79
1653	1656	115	Veal, leg	1.24	7.85	.52	.37	.59	1.31	......	......	.40
1664	1662	117	do	2.48	7.71	2.05	.76	2.56	2.22	......	......	.43
			Average Nos. 1653 and 1664	1.86	7.78	1.29	.57	1.58	1.77	......	......	.42
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	2.02	8.34	1.94	1.24	1.72	1.93	......	......	.50
1639	1637	107	Beef, round	1.61	8.39	......	......	2.36	5.21	......	......	......
1643	1647	110	do	1.96	8.37	......	......	2.16	2.84	......	......	.22
1721	1722	132	do	2.84	8.32	......	2.21	2.72	2.74	1.30	4.79	.52
			Average	2.14	8.36	......	......	2.41	3.60	......	......	.37
1704	1705	126	Beef, rump	4.93	8.43	......	3.09	4.84	4.30	2.38	6.39	.69
1652	1656	114	Veal, leg	2.51	6.17	1.48	1.13	2.02	2.20	......	......	.39
			Average Nos. 1639, 1643, 1652, 1704, and 1721	2.77	7.94	......	2.14	2.82	3.46	......	......	.46
			Average of all cooked 5 hours	2.12	8.20	[a]1.75	1.37	1.98	2.27	......	......	.43
			Average of all cooked 3 or 5 hours	[b]1.60	[b]8.09	......	[c]1.11	1.54	1.87	[d]1.19	......	[e].42

[a] Average of 8 analyses.

[b] Average of 30 analyses.

[c] Average of 24 analyses.

[d] Average of 18 analyses.

[e] Average of 28 analyses.

TABLE 136.—*Nitrogen records of the clear, filtered broth (expressed in percentage of total nitrogen in broth).*

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Total nitrogen in cooked meat.	Total nitrogen in broth.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$.
				At beginning.	During cooking.							
				°C.	°C.	Hrs.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
1642	1640	109	Beef, round	Cold.	85	3	5.770	100	0.23	7.63	7.86	......
1754	1753	137	.....do	Cold.	85	3	5.884	100	0	9.12	9.12	......
			Average	Cold.	85	3	5.827	100	.12	8.38	8.49	......
1756	1753	139	Beef, round (browned).	Cold.	85	3	5.495	100	0	8.91	8.91	......
			Average Nos. 1642, 1754, and 1756	Cold.	85	3	5.716	100	.08	8.55	8.63	......
1746	1741	136	Beef, round (browned).	85	85	3	5.696	100	.27	11.04	11.30	......
1769	1764	145	Beef, round	85	85	3	5.810	100	.79	9.14	9.92	......
1780	1775	154	.....do	85	85	3	6.040	100	1.49	6.40	7.89	......
			Average Nos. 1769 and 1780	85	85	3	5.925	100	1.14	7.77	8.91	......
			Average Nos. 1746, 1769, and 1780	85	85	3	5.849	100	.85	8.86	9.70	......
1641	1640	108	Beef, round	100	85	3	5.910	100	0	9.29	9.29	......
1744	1741	134	.....do	100	85	3	5.862	100	.19	13.55	13.74	......
1768	1764	144	.....do	100	85	3	5.309	100	1.13	8.63	9.76	......
1779	1775	153	.....do	100	85	3	6.013	100	2.10	7.81	9.91	......
			Average	100	85	3	5.774	100	.86	9.82	10.68	......
1755	1753	138	Beef, round	Cold.	100	3	5.857	100	0	12.70	12.70	......
1757	1753	140	Beef, round (browned).	Cold.	100	3	5.855	100	0	12.08	12.08	......
			Average	Cold.	100	3	5.856	100	0	12.39	12.39	......
1743	1741	133	Beef, round	100	100	3	5.834	100	.35	16.10	16.45	......
1745	1741	135	Beef, round (browned).	100	100	3	5.556	100	.19	16.57	16.76	......
			Average	100	100	3	5.695	100	.27	16.34	16.61	......
			Average of all cooked 3 hours.	......	......	3	5.778	100	.48	10.64	11.12	......
1646	1647	113	Beef, round	Cold.	65	5	5.240	100	3.50	6.79	10.29	0.91
1645	1647	112	.....do	Cold	85	5	5.420	100	.32	5.81	6.13	.73
1654	1656	116	Veal, leg	Cold.	85	5	5.070	100	.59	16.21	16.80	4.30
1658	1662	118	.....do	Cold	85	5	4.800	100	.52	21.01	21.53	.71
			Average Nos. 1654 and 1658	Cold.	85	5	4.935	100	.56	18.61	19.17	2.51
			Average Nos. 1645, 1654, and 1658	Cold.	85	5	5.097	100	.48	14.34	14.82	1.91
1644	1647	111	Beef, round	100	85	5	5.590	100	.46	9.70	10.16	.54
1720	1722	131	.....do	100	85	5	5.309	100	0	13.14	13.14	......
			Average	100	85	5	5.450	100	.23	11.42	11.65	......
1665	1668	121	Beef, neck	100	85	5	5.039	100	1.07	......	......	1.25
1673	1676	123	Beef, rump	100	85	5	3.245	100	.33	19.98	20.30	.69
1703	1705	125	.....do	100	85	5	4.433	100	1.21	15.15	16.36	......
			Average Nos. 1673 and 1703	100	85	5	3.839	100	.77	17.57	18.33	......

TABLE 136.—*Nitrogen records of the clear, filtered broth (expressed in percentage of total nitrogen in broth)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Temperature.		Duration of cooking.	Total nitrogen in cooked meat.	Total nitrogen in broth.	Nitrogen coagulated by heat.	Nitrogen precipitated by $ZnSO_4$ (albumose).	Sum of coagulable and albumose nitrogen.	Nitrogen precipitated by bromin in filtrate from $ZnSO_4$.
				At beginning.	During cooking.							
				°C.	°C.	Hrs.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
1669	1672	122	Beef, flank	100	85	5	3.210	100	0.68	33.92	34.60	0.65
1653	1656	113	Veal, leg	100	85	5	5.360	100	1.40	7.30	8.69	4.92
1664	1662	117	.....do	100	85	5	4.900	100	.52	22.90	23.42	.88
			Average Nos. 1653 and 1664	100	85	5	5.130	100	.96	15.10	16.06	2.90
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	100	85	5	4.636	100	.71	17.44	18.10	1.49
1639	1637	107	Beef, round	100	100	5	5.640	100	.50	15.63	16.13	....
1643	1647	110	.....do	100	100	5	5.370	100	1.01	17.06	18.07	.87
1721	1722	132	.....do	100	100	5	5.324	100	0	25.42	25.42	....
			Average	100	100	5	5.445	100	.50	19.37	19.87	....
1704	1705	126	Beef, rump	100	100	5	4.583	100	.92	36.02	36.94	....
1652	1656	114	Veal, leg	100	100	5	5.310	100	.56	23.43	23.99	4.91
			Average Nos. 1639, 1643, 1652, 1704, and 1721	100	100	5	5.245	100	.60	23.51	24.11	....
			Average of all cooked 5 hours	......	......	5	4.932	100	.80	18.09	18.88	[a] 1.78
			Average of all cooked 3 or 5 hours	......	......	......	5.314	100	.66	[b] 5.81	[b] 15.26	....

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Proteid nitrogen in broth.	Nonproteid nitrogen in broth.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt.	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen precipitated by alcohol.	Nitrogen as free ammonia.
				P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
1642	1640	109	Beef, round	7.86	92.14	......	......	7.66	32.23	......	......	......
1754	1753	137	.....do	9.12	90.88	......	9.87	9.35	12.18	16.82	......	4.51
			Average	8.49	91.51	......	9.87	8.51	22.21	16.82	......	4.51
1756	1753	139	Beef, round (browned)	8.91	91.09	......	9.30	9.07	11.49	15.63	......	4.41
			Average Nos. 1642, 1754, and 1756	8.63	91.37	......	9.59	8.69	18.63	16.23	......	4.46
1746	1741	136	Beef, round (browned)	11.30	88.70	......	9.35	10.54	11.23	5.54	......	3.88
1769	1764	145	Beef, round	9.92	90.08	......	8.05	10.52	11.12	13.37	......	4.31
1780	1775	154	.....do	7.89	92.11	......	8.87	4.98	7.89	14.21	......	4.95
			Average Nos. 1769 and 1780	8.91	91.09	......	8.46	7.75	9.51	13.79	......	4.63
			Average Nos. 1746, 1769, and 1780	9.70	90.30	......	8.76	8.68	10.08	11.04	......	4.38
1641	1640	108	Beef, round	9.29	90.71	......	......	10.38	33.29	......	......	......
1744	1741	134	.....do	13.74	86.26	......	10.83	12.10	17.15	5.61	......	4.00
1768	1764	144	.....do	9.76	90.24	......	7.92	8.38	11.39	13.82	......	3.94
1779	1775	153	.....do	9.91	90.09	......	8.96	4.21	7.73	12.94	......	3.71
			Average	10.68	89.32	......	9.24	8.77	17.39	10.79	......	3.88

[a] Average of 12 analyses.

[b] Average of 30 analyses.

Table 136.—*Nitrogen records of the clear, filtered broth (expressed in percentage of total nitrogen in broth)*—Continued.

Laboratory No.	Raw meat used No.	Cooking experiment No.	Kind of meat.	Proteid nitrogen in broth.	Nonproteid nitrogen in broth.	Nitrogen precipitated by bromin directly.	Nitrogen precipitated by phosphotungstic acid (hot).	Nitrogen precipitated by tannin and salt	Nitrogen precipitated by phosphotungstic acid (cold).	Nitrogen precipitated by Stutzer's reagent.	Nitrogen precipitated by alcohol.	Nitrogen as free ammonia.
				P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1755	1753	138	Beef, round	12.70	87.30	......	13.01	12.89	13.04	16.28	......	5.54
1757	1753	140	Beef, round (browned)	12.08	87.92	......	11.19	9.68	12.39	14.82	......	5.41
			Average	12.39	87.61	......	12.10	11.29	12.72	15.55	......	5.48
1743	1741	133	Beef, round	16.45	83.55	......	8.11	25.83	7.81	6.99	......	4.58
1745	1741	135	Beef, round (browned)	16.76	83.24	......	9.79	17.11	17.27	8.81	......	5.04
			Average	16.61	83.39	......	8.95	21.47	12.54	7.90	......	4.81
			Average of all cooked 3 hours	11.12	88.88	......	9.61	10.91	14.73	12.07	......	4.52
1646	1647	113	Beef, round	11.20	88.80	......	......	11.62	13.19	......	......	.72
1645	1647	112	....do	6.86	93.14	......	......	10.56	11.29	......	......	1.26
1654	1656	116	Veal, leg	21.10	78.90	10.16	6.38	11.91	11.49	......	......	3.94
1658	1662	118	....do	22.24	77.76	20.68	7.55	25.21	20.49	......	......	4.36
			Average Nos. 1654 and 1658	21.67	78.33	15.42	6.97	18.56	15.99	......	......	4.15
			Average Nos. 1645, 1654, and 1658	16.73	83.27	......	......	15.89	14.42	......	......	3.19
1644	1647	111	Beef, round	10.70	89.30	......	......	10.79	18.61	......	......	1.85
1720	1722	131	....do	13.14	86.86	......	13.80	13.63	15.43	12.40	32.83	3.34
			Average	11.92	88.08	......	......	12.21	17.02	......	......	2.60
1665	1668	121	Beef, neck	......	......	11.08	8.31	13.45	17.65	......	......	8.27
1673	1676	123	Beef, rump	20.99	79.01	28.78	16.71	11.86	13.78	......	......	5.50
1703	1705	125	....do	16.36	83.64	......	17.36	15.69	17.81	9.89	28.00	5.96
			Average Nos. 1673 and 1703	18.68	81.33	......	17.04	13.78	15.30	......	......	5.73
1669	1672	122	Beef, flank	35.25	64.75	28.92	15.70	36.69	32.84	......	......	7.02
1653	1656	113	Veal, leg	13.61	86.39	5.77	4.03	6.44	14.40	......	......	4.54
1664	1662	117	....do	24.30	75.70	20.08	7.47	25.15	21.75	......	......	4.24
			Average Nos. 1653 and 1664	18.96	81.04	12.93	5.75	15.80	18.08	......	......	4.39
			Average Nos. 1644, 1653, 1664, 1665, 1669, 1673, 1703, and 1720	19.20	80.81	18.93	11.91	16.72	18.91	......	......	5.09
1639	1637	107	Beef, round	16.13	83.87	......	......	23.56	52.03	......	......	......
1643	1647	110	....do	18.94	81.06	......	......	20.97	27.47	......	......	2.11
1721	1722	132	....do	25.42	74.58	......	19.79	24.42	24.52	11.65	42.91	4.68
			Average	20.16	79.84	......	......	22.98	34.67	......	......	3.40
1704	1705	126	Beef, rump	36.94	63.06	......	23.11	36.20	32.16	17.77	47.85	5.15
1652	1656	114	Veal, leg	28.91	71.09	17.03	12.98	23.30	25.39	......	......	4.55
			Average Nos. 1639, 1643, 1652, 1704, and 1721	25.27	74.73	......	18.63	25.69	32.31	......	......	4.12
			Average of all cooked 5 hours	20.13	79.87	[a]17.82	12.77	18.91	21.72	12.93	[b]37.90	4.22
			Average of all cooked 3 or 5 hours	[c]15.93	[c]84.07	......	[d]11.19	15.30	18.56	[e]12.29	......	[f]4.35

[a] Average of 8 analyses.
[b] Average of 4 analyses.
[c] Average of 30 analyses.
[d] Average of 24 analyses.
[e] Average of 16 analyses.
[f] Average of 28 analyses.

From Table 134 it will be seen that the clear, filtered broths contain from 0.2238 to 0.3787 per cent total nitrogen, the average being 0.3144 per cent. These figures compared with those in Table 108 show that the amount of total nitrogen in clear meat broths is much less than that contained in the cold-water extracts of uncooked meats, when the results are expressed upon the same basis.

The nitrogen found in the clear, filtered broths in the form of proteids coagulable by heat in neutral solution varies from none in a number of cases to 0.0116 per cent, the average being 0.0020 per cent; the albumose nitrogen precipitated with zinc sulphate ranged from 0.0163 to 0.1364 per cent, averaging 0.0470 per cent of the entire weight of the fresh meats; the soluble proteid nitrogen varied from 0.0201 to 0.1399 per cent, the average being 0.0510 per cent, and the nonproteid nitrogen in the clear broths ranged from 0.1798 to 0.3409 per cent, averaging 0.2664 per cent.

A small quantity of nitrogen was present as ammonia or ammonium salts, the average amount being 0.0133 per cent.

The average quantities of nitrogen precipitated by various reagents from clear broths were: Bromin 0.0512 per cent, phosphotungstic acid in a hot solution 0.0349 per cent, phosphotungstic acid in a cold solution 0.0602 per cent, tannin and salt 0.0492 per cent, and Stutzer's reagent 0.0384 per cent.

In Table 135 the nitrogen records of the clear broths are given in the form of percentages of the total nitrogen contained in the uncooked flesh. It will be there noted that the total nitrogen found in the clear broths forms from 7.22 to 13.36 per cent of the total nitrogen contained in the uncooked meat. The average amount of soluble nitrogen in the 31 samples of clear broths was 9.61 per cent of the total nitrogen. The average quantity of soluble nitrogen in the raw meats was 22.14 per cent, and the average amount of soluble nitrogen in the 31 samples of boiled meats was 4.71 per cent of the total nitrogen.

The average values for the different nitrogenous constituents are also given.

These data presented for the clear broths calculated in percentages of the total soluble nitrogen show that in a considerable number of cases there was no nitrogen in the form of compounds coagulated by heat, while in others the quantity of nitrogen in this form reaches 0.35 per cent, the average being 0.06 per cent.

The data for the other forms of nitrogen may also be readily learned from Table 136. The general conclusion from all these considerations of the character of the nitrogenous constituents of clear, filtered broths is that, as compared with raw and boiled meats, they are present largely as extractives and to but a slight extent in proteid forms.

CONCLUSIONS.

The principal conclusions which can be drawn from the studies of meat and meat products reported in this bulletin are the following: Meats of different kinds and cuts may be analyzed directly and with accuracy—that is, without being first previously air dried. The soluble matter in meats may be completely removed by extraction with cold water and the preparation and analysis of such cold-water extracts is of great importance in studies of the true value of flesh foods. The total proportion of raw meat which is soluble in cold water is considerable, the average results showing that the cold-water extract contains about 2.3 per cent proteid, 1 per cent nitrogenous extractives, 1.6 per cent nonnitrogenous extractives, 0.7 per cent nitrogen, and 0.8 per cent ash. None of the fat present in the meat is dissolved by cold water. The proportion of each nutrient present in the original flesh which is dissolved in cold water is, on an average, proteid 13 per cent; organic extractives, including both nitrogenous and nonnitrogenous compounds, 100 per cent; ash, 81 per cent; total nitrogen, 22 per cent. Of the nitrogen compounds soluble in cold water, 46 per cent is coagulated by heat. The nitrogen present is about equally divided between proteid and nonproteid bodies.

Meats cooked by boiling are less soluble in cold water than are raw meats, the average amount of nutrients recovered in the extract as compared with the total weight of the meats used being 0.4 per cent proteid, 0.6 per cent nitrogenous extractives, 0.8 per cent nonnitrogenous extractives, 0.3 per cent nitrogen, and 0.4 per cent ash. The average ratio of nonproteid to proteid nitrogen is as 1:0.31. Expressed as percentages of the amount of each nutrient originally present, the average values for the cold-water extract of cooked meats are 1 per cent proteid, 100 per cent extractives including both nitrogenous and nonnitrogenous compounds, 67 per cent ash, and 1 per cent nitrogen. As in the case of raw meat, no fat is dissolved by the cold water.

The different methods commonly followed in cooking meat in hot water vary somewhat as to time and temperature of cooking, but the resulting cooked meats are quite similar as regards composition and also as regards the proportion of their constituents which are soluble in cold water.

Meats cooked by dry heat, as in roasting, broiling, sautéing, and frying, are on an average 2.4 times more soluble in water than boiled meats but are only a little more than half as soluble as raw meats. The results show that on an average cold water removes the following percentage amounts from meats cooked by dry heat: Proteid 0.7, nitrogenous extractives 1.3 nonnitrogenous extractives 1.6, nitrogen 0.5, and ash 1 per cent. Considered on a water-free basis, roast meats contain about 2.3 times as much soluble proteid and nonnitrogenous extractives and 2.5 times as much nitrogenous extractives and ash as boiled meats.

The more pronounced flavor of meats cooked by dry heat as compared with those cooked in hot water is without doubt due to the larger proportion of soluble constituents which the former contains. As regards the losses in weight when meat is cooked in hot water, the average values show that it is equal to from 10 to 50 per cent of the total weight of the fresh meat used, the average being about 34 per cent. The amount of water removed by the heat of boiling ranges from about 18 to 69 per cent, the average being 45 per cent of the amount originally present. The total protein removed in the broth varies from 3 per cent to 13 per cent, averaging 7 per cent. The proportion of fat originally present in the raw meat which is recovered in the broth varies from 0.6 to 37 per cent, and the proportion of mineral matter from 20 to 67 per cent, averaging not far from 45 per cent. The nutrients in the broth expressed as percentages of the total weight of the uncooked meat on an average equal, water 31, proteid 1, fat 1, and ash 0.5 per cent. The fatter kinds and cuts of meat lose less water, proteid, and mineral matters, but more fat than leaner kinds of meat. The proportion of nutrients extracted in the broth is directly proportional to the length of time and the temperature of the cooking period. Different cuts of some kinds of meat behave differently as regards the nature and amount of the losses they sustain when cooked in hot water. On an average, the larger the piece the smaller the percentage losses. When meat is cooked in water at 80 to 85° C., placing the meat in hot or cold water at the start has little effect on the amount of material recovered in the broth. Beef used in the preparation of beef tea or broth has lost comparatively little of its total nutritive material, though most of the constituents which give flavor have been removed. The experimental data indicate that on an average 72 per cent of the nitrogenous organic extractives originally present in beef is removed during boiling, and that the average of nonnitrogenous organic extractives removed is also 72 per cent. When meats are cooked by dry heat the losses sustained are much smaller than when cooked in hot water, being, on an average, water, 35 per cent; nitrogenous extractives, 9 per cent; nonnitrogenous extractives, 17 per cent; fat, 7 per cent, and ash, 12 per cent. On an average there was an apparent gain of 4 per cent proteid, this apparently anomalous value being probably due to unavoidable faults in the experimental methods or some similar cause.

As regards the composition of complete or unfiltered meat broths, the average results vary, the total solid matter containing from 1 to 10 per cent of the total quantity of meat used. On an average the percentage composition of a large number of broths was, water, 97 ; total solids, 3; proteid, 0.3; nitrogenous extractives, 0.6; nonnitrogenous extractives, 0.7; total organic extractives, 1.3; fat, 1.3, and ash 0.5 per cent. On an average 0.24 per cent of the total nitrogen was present as proteids and 0.18 per cent as nonproteid bodies. The clear, filtered broths contained less of the important food elements, i. e., proteids and fat, than complete or unfiltered broths, but practically the same amounts of the different extractive bodies and ash. In other words, they have less food value but fully as much flavor as the unfiltered broths, provided the fat is removed in both cases. Meat fat possesses more or less distinctive flavor, and if present modifies the flavor of the broth. Both filtered and unfiltered broths have a low food value as compared with the meats from which they are made, or as compared with meats cooked by dry heat or in hot water. This is obvious when it is remembered that broth or soup is made up largely of water.

The small amount of nutritive material in broth or soup is chiefly in the form of organic extractives. The richness of the broth increases as the size of the pieces of meat used in making it decreases. An increase in the time of cooking also increases the amount of nutrients found in the broth. The broth is very little richer when made from bones as well as meat, the chief nutrients thus added being fat and soluble proteid.

In general the various methods of cooking materially modify the appearance, texture, and flavor of meat and hence its palatability, but have little effect on total nutritive value. Whether it be cooked in hot water, as in boiling or stewing, or by dry heat, as in roasting, broiling, sautéing, or frying, meat of all kinds has a high food value when judged by the kind and amount of nutritive ingredients which are present.

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 163.

A. C. TRUE, Director.

AGRICULTURAL INSTRUCTION FOR ADULTS IN CONTINENTAL COUNTRIES.

BY

JOHN HAMILTON,

FARMERS' INSTITUTE SPECIALIST.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 163.

A. C. TRUE, Director.

AGRICULTURAL INSTRUCTION FOR ADULTS IN CONTINENTAL COUNTRIES.

BY

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JOHN HAMILTON,
FARMERS' INSTITUTE SPECIALIST.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., October 12, 1905.

SIR: The following bulletin on Agricultural Instruction for Adults in Continental Countries, by John Hamilton, farmers' institute specialist of this Office, has been prepared with a view to directing the attention of farmers' institute workers to the methods that have been adopted and found useful by continental governments in affording educational facilities to their adult agricultural population.

The bulletin is in effect a supplement to one (No. 155) recently issued by this Office on Agricultural Instruction for Adults in the British Empire, and is in compliance with a requirement of the act of Congress making provision for the appointment of a farmers' institute specialist in the Department, and defining his duties to be "to investigate and report upon the organization and progress of farmers' institutes in the several States and Territories, and upon similar organizations in foreign countries."

The manuscript is recommended for publication as Bulletin No. 163 of this Office.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

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AGRICULTURAL INSTRUCTION FOR ADULTS IN CONTINENTAL COUNTRIES.

INTRODUCTION.

In most continental countries the majority of the population are engaged in agriculture, and in a number as much as 75 per cent depend directly upon farming for their livelihood. It is to be expected, therefore, that where so large a portion of the population is engaged in this industry special attention would be given by the governments of these countries to the interests of the farming people. In many of them the virgin lands were long ago occupied, and now no new soil is to be had except such as may be wrested from the sea, reclaimed from swamps, or taken from the desert.

Because of this restricted area of cultivated land, it was quite manifest that unless some means could be devised by which the same soil century after century could be brought to produce crops with unfailing regularity and in constantly increasing abundance, the country must eventually become uninhabitable and the State consequently cease to exist, for it is an historic fact that only nomadic tribes can live in a region where agriculture has ceased to be a profitable pursuit. All of this has been so generally understood and appreciated by foreign nations that long ago their governments gave most careful attention to the subject of animal and plant production, with the result that without exception they have reached the conviction that the only solution of the question of improving agriculture sufficiently to enable those who pursue it as a calling to maintain themselves in comfort for all time to come, and also to produce a surplus for use by those engaged in other occupations, lies in the proper education of those who conduct its operations.

Accordingly schools and colleges of agriculture were established in some countries more than a century ago, and now few foreign nations are without institutions established and in part or altogether maintained by the State for the purpose of discovering agricultural truth and for disseminating this truth among the masses. In many of them the number of such institutions runs into the hundreds.

No more interesting or significant feature is brought out in the study of the agriculture of foreign lands than the fact that in every country all of the people—the peasantry, the landed proprietors, as well as those who administer the laws—now look to their agricultural educational institutions not only for the solution of present problems in production, but also for the discovery of new facts and new methods that will insure increased and more profitable crops in the time to come.

The sincerity and strength of this sentiment is shown in the measures that have been adopted by the governments of these countries for the perfecting of their systems of agricultural education, as exhibited in the statements which appear in this bulletin. State departments of agriculture have been established and equipped with expert officials who devote all of their time to the interests of agriculture. Universities, colleges, normal schools, academies, secondary schools, common schools, and numerous special classes are everywhere in operation, and in almost all of them the giving of instruction in agriculture is made obligatory. In most countries these institutions are aided and in a number are wholly supported by the State. The governments also encourage the formation of local agricultural organizations, such as cooperative associations for special purposes, societies for holding agricultural shows, credit societies, agricultural insurance companies, etc., and in most cases grant them financial aid.

The attention of farmers' institute workers is particularly called to some features of the work abroad that are characteristic and specially worthy of careful consideration.

The first is the extreme care with which the itinerant instructors in foreign countries are selected. In two countries the age qualification is an important item, no one being accepted under 25 years. In several a competitive examination is required to be held by a committee of experts, and only those passing are permitted to be employed. In every country some special qualification is necessary before the institute teacher can enter upon this service.

Another point worthy of attention is the method of supervision that exists in every country. There is everywhere a central supervisory authority which holds the local officers and institute teachers and workers to strict account for the efficiency and success of the work.

A third important item is the system of personal visitation by specialists made to farms and communities for the purpose of giving assistance through expert advice. In France particularly this feature of the work is emphasized, and its effect is seen in what that country has done since this form of aid was undertaken.

Attention is also called to the various methods in use in disseminating agricultural information. There is, first of all, the itinerant lecturer, who meets audiences of farmers and delivers one or more addresses, much as is now done in the farmers' institutes of the United States.

There is also the specialist, who conducts a movable school which is located in a community for two or three weeks and then is transferred to another center where a similar class is formed and the instruction repeated. Then there is the winter school, located in a rural community and continuing for several months, to which only adults are admitted. There are also agricultural high schools which only farming people who have had previous practical experience of at least one year upon a farm and considerable preliminary education can enter.

The system of support for the itinerant schools and for the lecturers is also worthy of careful study, as are also the methods adopted for securing the cooperation of local communities in the work of institute instruction. There are likewise the demonstration farms and fields organized by a central board having charge of the institute system of instruction, over which the itinerant institute teacher is placed, and which are used for instruction purposes in connection with the institute work in the several communities. Attention is specially called to the interest manifested and the part taken by the higher institutions of learning, especially by the universities and agricultural colleges, in itinerant instruction.

There is also the teaching of agriculture in the common schools made compulsory in most countries, and accompanied by the use of school gardens and experiment grounds for purposes of practical training and demonstration. Last of all, but by no means the least suggestive, there is the use of the monthly publication, edited and issued by the State as an official medium for disseminating agricultural information, free of cost, among the members of the farmers' institute societies of the country, keeping them informed with respect to the work of the various societies in their own as well as in other States.

AUSTRIA.

The distinguishing features of the farmers' institute system of Austria are briefly stated by the Austrian minister of agriculture in the following communication:

> The establishment of itinerant agricultural instruction in Austria is not very recent and the system in operation is regarded as an important factor in the professional education of the agricultural population above school age and is of especial valne in those parts of the country not provided with agricultural schools.
>
> This instruction is generally given by professional itinerant teachers of agriculture, appointed by the State, by the provincial administrations, or by the principal agricultural corporations in the different dependencies and provinces, but experts in the different lines of work closely connected with agriculture and agricultural pursuits are also employed for this purpose. The lectures are usually delivered at the meetings of agricultural societies, at agricultural expositions, stock shows, etc.
>
> The professional itinerant teachers receive a fixed remuneration for their services, including the salary and a lump sum for traveling expenses, amounting annually to from $720 to $960. The teachers appointed by the State are paid from the State treasury,

while those appointed by the provincial administrations and agricultural corporations receive their remuneration from the funds of the particular province or the private funds of the corporation. The provincial administration as well as the agricultural corporations receive annually very important subsidies from the State for the purpose of maintaining their itinerant agricultural instruction. The remuneration of the professional expert is adjusted for each particular case and the amount is governed by his standing in the line of work he represents and by the time he is employed.

This instruction does not always consist of single lectures, but very frequently courses of lectures lasting several days, and even weeks, on widely different phases of agriculture, are given. In this connection the courses on dairying, viticulture, orcharding, etc., may be mentioned as enjoying special popularity. These special courses are usually given under the auspices of local agricultural societies, which draw for this purpose adequate subsidies from State and provincial funds.

The special duties of the itinerant agricultural teachers, especially of those appointed by the State and following the work as a profession, are usually outlined in the contract or by particular rules relating to the service, and generally particular stress is laid upon keeping in touch with the agricultural population of the district and studying the wants and needs of the farmer instead of limiting themselves to delivering lectures and giving instructions at regularly appointed times.

Complete statistics on this phase of agricultural education can not be given, because the data of the ministry of agriculture are limited to those lectures and courses for which provision has been made by the State or General Government. Reports on particular courses frequently appear in the agricultural press of the country, but they are so numerous and so scattered that a compilation of them with a view to covering the field is a matter of great difficulty.

BELGIUM.

There is an agricultural society in each province in Belgium, in addition to the Central Agricultural Society of the Kingdom. Each of the provincial societies holds annually an agricultural show or fair, and a number of them have organized lecture courses upon agricultural subjects, conducted by expert agriculturists who visit the various sections and give instruction upon subjects arranged under the following classification: (1) Agriculture for adult farmers and farmers' wives; (2) agriculture for soldiers; (3) farriery; (4) arboriculture and market gardening; (5) apiculture; (6) aviculture, and (7) miscellaneous lessons and special lectures. There are also movable dairy schools for women.

The movable schools in agriculture were begun in 1887. Since the organization of these courses up to 1903 3,643 lectures have been given, attended by 163,055 pupils. In 1902 schools for women were introduced, the lectures treating on household economy, hygiene, dairy farming, household and farm bookkeeping, aviculture, gardening, and the canning and preserving of fruits. During that year 16,312 persons attended these schools of domestic economy.

AGRICULTURE FOR ADULT FARMERS AND FARMERS' WIVES.

The courses of lectures given in the schools for farmers embrace the following subjects: The soil; seeds and their germination; agricultural hydraulics; elements of agricultural physiology and chemistry; special crops; cattle foods and feeding; hygiene; zootechny; dairying; agricultural bookkeeping; rural laws; rural economy; mutual insurance and cooperation; and agricultural institutions.

COURSES OF LECTURES IN AGRICULTURE FOR SOLDIERS.

Instruction in these courses follows practically the same outline of subjects as that given to farmers, except that instead of 30 lectures being delivered as in the case of farmers, the soldiers' course is limited to 22.

The taking of these lectures by the soldiers is entirely voluntary, those who attend not being exempted from any of the regular military duties. Rewards are offered by the agricultural department to those soldiers who obtain the most marks in a special examination on agricultural subjects, and on the recommendation of the lecturer agricultural books are given to the pupils who are most attentive. The reports show that during the last three years 86 courses of lectures have been given to soldiers, and that these have been attended by 2,195 men.

COURSES OF LECTURES IN FARRIERY.

Classes of pupils in farriery are organized every year and instruction is given, beginning early in January, continuing through twelve lessons. Four of these lessons are reserved for giving practical demonstrations in horseshoeing. The pupils are required to pass an oral and also a practical examination before a commission composed of the veterinary inspector, the State agriculturist of the district, and the professor in charge of the course. Certificates of proficiency are given to those only who obtain at least five-tenths of the marks allotted to the theoretical examination, and six-tenths of those allotted to the practical examination. This certificate admits the pupils to the Central Practical Farriery School at Brussels.

Before a course of lectures on farriery can be organized at least twelve pupils must have registered their names, agreeing to attend the entire series of lectures.

COURSES OF LECTURES IN ARBORICULTURE AND MARKET GARDENING.

The programme of the course in arboriculture and market gardening consists of fifteen lectures in arboriculture and a number of lessons in market gardening. The communal municipalities or the horticultural societies who ask for these lectures must agree to furnish a sufficiently large room for class purposes and a moderate-sized fruit garden, placing them at the disposal of the lecturer. The courses are only given where an attendance of at least 20 is guaranteed. Examinations are held, and to those who pass certificates are awarded by the board of examination. Between 1895 and 1903, 1,628 pupils have been up for this examination, of whom 731 obtained certificates for arboriculture and 104 for market gardening.

COURSES OF LECTURES IN APICULTURE.

Until 1902 lectures upon apiculture were equally divided among the districts where members of apicultural societies existed. From that date these lectures have been given in a series of at least five in the same locality. During the last three years 1,574 lessons have been given and the courses were attended by 3,000 persons.

COURSES OF LECTURES IN AVICULTURE.

Four or five lectures comprise the course on aviculture. The first course on this subject was prepared by the inspector of agriculture, and required that the lecturers should pass an examination before being permitted to give instruction. The courses at present are prepared by the various societies interested in the subject. The popularity of the study is shown by the fact that during the past three years 924 lessons were given and the courses were attended by about 20,000 pupils.

SPECIAL LESSONS AND SPECIAL LECTURES.

In addition to the foregoing courses, the department of agriculture has granted subsidies providing for a certain number of special lessons, as upon the choice and feeding of dairy cows; lessons in agricultural chemistry; agricultural bookkeeping; lectures on the natural sciences in their application to agriculture, etc. Eight hundred and fifty lectures of this character have been given during the last three years, the courses all having been organized by the local agricultural associations.

MOVABLE DAIRY SCHOOLS FOR WOMEN.

On a Belgian farm the farmer's wife looks after the dairy. For this reason the teaching of the feeding and care of cattle and the elements of dairy farming have been made a feature in the movable dairy schools for women. These dairy schools are movable, changing their location from one agricultural district to another once every three months. The first school was founded in 1890, and at present ten are reported as being in active operation.

The establishment of the movable dairy school is usually made at the request of the local agricultural associations, and is supported either directly by the State or through the provincial association of the district. The teaching is both theoretical and practical. Instruction is given every day except Sundays, two hours being devoted to the study of the theory and three hours to practical work. The number of pupils is limited to 20, and the attendance at the course is free of charge. A Government grant of 2,000 francs is awarded to these schools for a three-months' course. The applicant must be at least 15 years old, possess a good elementary education, and be in physical condition to do the work taught in the schools. Since the foundation of the school in 1890, over 2,000 diplomas have been awarded. The course at present lasts for four months, and the teaching of domestic economy and aviculture has been included in the programme.

In addition to the system of direct instruction given through the movable schools, every agricultural district committee in Belgium is authorized to establish at the expense of the Government two fields each year for experiments and demonstrations in agriculture, one to be used for spring crops and the other for autumn planting. The fields are limited to one-half acre each in area. The character of the experiments is determined by the delegate appointed by the district committee, conjointly with a State agricultural expert. The latter determines the varieties of seed, roots, or manures to be experimented with. This committee selects the agriculturist upon whose land the field is to be established, and, inasmuch as the fields are intended to supplement the theoretical instruction given in the movable schools, they are usually located in proximity to the centers at which these schools are held.

The farmer upon whose estate the field is established must place at the disposal of the committee half an acre of land gratuitously, and agree to treat the soil according to the direction of the committee, also to furnish gratuitously the necessary farmyard manure. The department of agriculture supplies free of charge the seeds, roots, and chemical manures. The State expert prescribes the character of the cultivation to be followed and gives specific directions for the care of the crop, to which directions the farmers must agree to conform. The crop, when raised, is the property of the cultivator, excepting that the State expert can take samples if he wishes to do so.

In addition to the foregoing, the cultivator agrees to grow in the following year at his own expense the variety of crop which shall have yielded the best returns as regards quality and quantity.

A similar decree exists respecting the establishing of gardens for experiment purposes in connection with each provincial agricultural society. These gardens are to be used for the growing of new varieties of seeds, roots, etc., with the understanding that the varieties recognized as good shall be distributed throughout the province by means of the fields for experimentation established in each agricultural district.

BULGARIA.

The three agricultural colleges and the three agricultural experiment stations of Bulgaria employ and send out itinerant teachers through the country districts to hold schools continuing for from one to two weeks, confining the instruction in any one school to a single topic, as dairying, apiculture, forestry, etc.

The itinerant teachers connected with the agricultural colleges and experiment stations are employed for the special purpose of conducting institute schools. When not engaged in this rural teaching the work is given them at the college or experiment station.

DENMARK.

The remarkable progress of agriculture in Denmark and its present high state of development are due to the careful attention which that country has given to the education of her farming people.

Denmark, excluding the Faroe Islands, has an area of only 14,789 square miles—about half as much as the State of Maine or almost exactly the size of Maryland and Connecticut combined. The population of Denmark in 1901 was 2,447,441; that of the two States last named was 2,096,464 in 1900.

The commercial importance of the Kingdom lies almost wholly in her agriculture, which in the last thirty years has risen from about the lowest to the highest place among the countries of Europe. In 1860 the British vice-consul at Copenhagen reported that "the butter, or the articles sold in the market by the yeomen-farmers under that name, is execrably bad." At present "Danish butter," "Danish bacon," and "Danish eggs" stand in price and quality at the top in the English markets.

Mr. Gill (secretary of the department of agriculture for Ireland), after a careful inspection of Danish methods, states that "what may be termed the essentials of agricultural progress are illustrated there, namely, (1) highly trained intelligence, enterprise, and resourcefulness; (2) the power given to the farmers by organization; and (3) the effectiveness with which the Government is able, chiefly through these organizations among farmers, to aid them with expert advice, technical instruction, and material support."

Inasmuch as Denmark is perhaps the most conspicuous example of what education of the rural people can do for the commercial development of a country, it may be well to present in some detail the system that has wrought the change that has taken place in this Kingdom in recent years.

UNIVERSITY.

At the head of the entire educational system is the Royal University at Copenhagen, with an attendance of over 1,300 students.

There is, also, the Royal Agricultural and Veterinary College of Copenhagen. This institution dates back to 1773, and was known as the Royal Veterinary School, to which there was added in 1856 a course of instruction in agriculture, and its name changed to that of The Royal Agricultural and Veterinary College. The institution is controlled and supported entirely by the Government. In addition to this central college there are 21 agricultural and horticultural schools in the country, with a total attendance of about 4,000 students.

EXPERIMENT STATIONS.

In addition to these institutions there are four experiment farms for research in agriculture, and over 500 demonstration fields distributed over the country for testing varieties of grains and forage crops, determining the value of various manures, the best methods of soil treatment, etc.

PEOPLE'S HIGH SCHOOLS.

There are also 78 people's high schools, with a reported attendance of about 6,000 students. These people's high schools originated in Denmark in 1844. They were founded by patriotic farmers who wished to create more interest in the national life on the part of the young men and women of the rural districts.

Admission to the schools was limited to persons over 18 years of age, who were required to have had experience in practical farming extending over at least one year. There were taught at the first in these schools the usual subjects of study found in the scheme of general education of that period, excepting that special attention was given to the study of the history and literature of Denmark, and the students were in addition made acquainted with her lyric poetry and popular songs. Later, studies in agriculture were added until now the courses of many of the schools are made up chiefly of such branches of science as relate to some phase of agricultural production.

The five winter months are devoted to the teaching of men, and the three spring and summer months to giving instruction to women.

COMMON SCHOOLS.

There are also the common rural schools that children from 7 to 14 years of age are obliged to attend.

COOPERATIVE SOCIETIES.

Another notable feature of the industrial system of Denmark, and it is in great measure the outgrowth of the educational methods that have been adopted, is the system of cooperative societies. In 1903 there were 3,556 cooperative agricultural societies in Denmark, with a membership of 509,424; horse-breeding societies, cattle-breeding societies, swine-breeding societies, milk-control unions, egg-collecting societies, societies for the purchase of feeding stuffs and manures, cooperative abattoirs, loan societies or credit banks—all on the cooperative plan.

LOCAL AGRICULTURAL SOCIETIES.

There are in addition 107 local agricultural societies, with a membership of 64,800. These local societies hold shows during the summer and have meetings for discussion during the winter. They also engage the services of experts to give advice to their members on farming matters, and some of them engage itinerant lecturers. Every fifth year these societies join with the Royal Agricultural Society in a national fête, consisting of a show, discussions, and excursions, continuing for five days. The societies of each province also have united into what are known as provincial unions. These unions hold yearly exhibitions.

The State aids all of these organizations. The amount averaged $450 to each local agricultural society in 1903, but the subsidies thus given are only in aid, and to be available must be supplemented by private subscriptions by the membership.

ALLIED AGRICULTURAL ORGANIZATIONS.

The form of alliance that exists among the agricultural organizations is fully and concisely stated by Dr. Herbert G. Smith in a paper read before the Cobden Club in 1901. In speaking of the organizations of Denmark he says:

> Chief among them is the Royal Danish Agricultural Society, founded in 1769, an organization which best represents the general agricultural opinion of the country, and which is the principal adviser of the Government in agricultural matters. It administers large sums on behalf of the Government, and also controls a large number of expert and other officers of the State. Its members may be classified as follows: (1) Individual members; (2) local agricultural cooperative societies; and (3) provincial unions or federations of local societies. Varying fees are paid by the members, which fees, with the Government grant, form the income of the Royal Danish Agricultural Society. A council of 36 members, with 3 presidents, forms the ruling body; 18 members of this council are elected by the local agricultural societies, and 18 by the individual members of the society. The number of local agricultural societies was (in 1895) 101, the average membership of each society being about 500. A whole county is sometimes represented by one society, while in other cases a group of parishes form a society. The larger parishes often contain four or five societies. The majority of these local societies have become federated into provincial unions, of which there are four—one for each province. Most of the members of the local cooperative societies are members both of their provincial union and the Royal Danish Agricultural Society.
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> In each province, in the autumn, a congress is held, to which delegates from the local societies are sent, and at which the agricultural interests of the province are discussed, and local opinion is formulated. Resolutions relating to measures which affect agriculturists are forwarded to the Government, which, as already said, consults the Royal Danish Agricultural Society in agricultural matters.

The provincial unions, however, being of opinion that the Royal Danish Agricultural Society does not, as at present constituted, sufficiently represent the general body of agriculturists, have created a council, composed of the presidents and vice-presidents of the provincial unions; for this council a position similar to that of the Royal Danish Agricultural Society, as adviser to the Government, is claimed. It is interesting to note that over half of the members of the Danish Parliament are peasant proprietors, and many of them have been educated at the high schools.

The Royal Danish Agricultural Society assists and acts as an intelligence department for the widely extended system of cooperative societies which are not yet affiliated to itself. As, however, the chief members of these societies are also members of the local affiliated societies and of the Royal Danish Agricultural Society, these unaffiliated societies in reality form a part of the cooperative organization of the country. The various local societies may be classified as follows: (1) Cooperative societies for bacon curing; (2) cooperative societies for collecting and exporting eggs (federated in 1895 into a large central society); (3) cooperative societies for breeding and rearing cattle, pigs, and horses; (4) cooperative dairy societies (about 1,200 in number); (5) cooperative bee-keeping societies, and (6) cooperative horticultural and fruit-growing societies. These societies are generously helped by the provincial unions and the Royal Danish Agricultural Society.

SYSTEM OF EXPERTS.

One of the most useful adjuncts to Danish agriculture is the system of employing experts who have proved very efficient in imparting scientific knowledge to farmers, and introducing uniform principles into agricultural production. In 1903 there were 25 of these experts in all, who cost the State over £8,000 per annum. In addition there were 27 experts appointed by the local agricultural societies, and partly paid by the State. The gratuitous advice of these experts can be obtained through the Royal Danish Agricultural Society. The 1,200 cooperative dairies, for instance, are frequently visited by them and repeated tests made on the relative qualities of the butter, etc., of the various dairies, the decision being communicated to all.

Danish experts also permanently reside in foreign countries for the purpose of keeping the Danish societies constantly informed of the requirements of foreign markets for agricultural produce.

As a striking instance of the advantages of organization, the following fact may be given: Recently it was considered desirable to introduce Yorkshire pigs into Denmark to improve the breed there, and a swine expert was sent to England, accompanied by representatives of the local Danish societies. Large purchases were made on behalf of both the Royal Danish Agricultural Society and the local societies, the expenses of the expert being contributed to by the Cooperative Bacon Curing Society and the Royal Danish Agricultural Society. Thus each Danish farmer was able, at a comparatively nominal expense to himself, to improve his swine.

MOVABLE AGRICULTURAL COURSES.

The feature of agricultural instruction in Denmark which corresponds most nearly to the system of agricultural institutes of the United States is the movable agricultural courses. These courses were originated by private initiative. The following statement, furnished by the Danish minister, shows the method of their operation:

> Every year the cooperating agricultural societies publish that they are willing to organize "movable courses" if a certain payment, suitable rooms for the teaching, and good maintenance for the teachers are guaranteed. When these conditions are

complied with the details as to time, etc., are settled directly between the applicants and the director of the course. There is no State official in charge of this work, but it is directed on behalf of the cooperating societies by the head master of the agricultural school at Lyngby, Sealand. He receives $216 a year from a private institution to superintend the work.

The director asks as many as possible of the experienced teachers of the agricultural schools and others, such as agricultural government advisers, veterinarians, etc., to act as lecturers. In 1903 twenty to thirty answered his call. To each course are detailed two or three lecturers, of whom one has taken part in former courses and is the head lecturer of the course.

Each course lasts two weeks, i. e., twelve days, with three lectures of forty minutes a day, and daily instruction in agricultural bookkeeping of seventy-five minutes. During the second week the lessons are followed by debating and question hours.

The lecturers are chosen by the director with due regard to the wishes of the pupils.

The lecturers get free transportation and all expenses. They are guaranteed $19 for one lecture a day and $26 for two.

Each member of the course pays a fee varying from $2 to $2.70, according to the number of members. They further pay 80 cents to $1 each for ledgers for bookkeeping, room, etc. If the fees exceed the expenses, the excess is divided between the lecturers.

From 1898 to 1902 all expenses were covered by the fees. From 1902 the Government has allowed $1,350, and from April 1, 1904, it has increased the amount to $2,700, to assist poor agriculturists to follow the courses.

The lecturers have other occupations, and they often only give lectures on one or a few of the courses.

During the year April 1, 1903, to March 31, 1904, twenty such courses were organized; more were requested, but could not be organized, owing to lack of lecturers. The courses were attended by 25 to 75 persons, or on an average by 50, which for 20 courses gives a total of about 1,000.

The cost for the students of each course was $80 to $100, exclusive of expenses for books, etc.

FRANCE.

The duty of providing instruction in agriculture for the people in the rural districts of France is recognized by the State, and has been made an important part of its system of public instruction. The primary and secondary schools, as well as the higher institutions of learning, are all required to teach this subject, the instruction varying in amount according to the grade of school and degree of preparation of the pupils.

The important place that agriculture occupies in the life of the French people is shown by the number engaged in this occupation. In a population of 38,517,975 in 1896, 6,600,000 were farmers, occupying 5,702,752 separate farms. A great majority of these farmers till comparatively few acres, 97 per cent of the farm properties in France consisting of less than 100 acres.

The work of giving agricultural instruction is thoroughly systematized, and arranged to reach all of the workers and their children with valuable information relating to their occupation. At the head of the system is the minister of education and fine arts, who is clothed with powers that enable him to hold all subordinates engaged in giving instruction to strict accountability for the efficiency of their work.

The civil divisions of France are, first, the commune, which is the elementary unit and varies in size according to the density of population in the locality. There is next the canton, made up of a number of communes, usually about 12. Then there is the arrondissement, composed of 8 cantons; and, including all of them, there is the department, made up of 4 arrondissements.

For school purposes the country is divided into 16 educational districts called academies. At the head of each academy is a rector, and at the head of each civil department constituting the academy is an academy inspector. Subordinate to these are the primary inspectors. The law also requires that there shall be, in each of the 87 civil departments into which the country is divided, at least one normal school for the preparation of teachers.

The giving of instruction in agriculture in all of the schools embraced by this educational system is made obligatory by the State. The studies to be taken up and the courses of lectures to be delivered must be approved by the minister of agriculture and commerce before they can be undertaken in any school. As a consequence the courses of instruction throughout the Republic, in all of the schools, even the most elementary, are systematically arranged and have been critically considered by capable authorities and formally approved by the minister and council of education.

DEPARTMENTAL AND SPECIAL PROFESSORS OF AGRICULTURE.

In the law reorganizing departmental and communal instruction enacted in 1879 it is directed that each "department," of which there are 87, shall be provided with one "departmental professor of agriculture," who is to be at least 25 years of age and is to be appointed from among the successful candidates who have passed a competitive examination for this position. The examination is written, oral, and practical; is arranged by the minister of agriculture and commerce in cooperation with the minister of public instruction and fine arts, and includes the different branches of agricultural science.

The departmental professors are divided into four classes according to salaries, as follows: First class, $877; second class, $780; third class, $682, and fourth class, $585. The first appointment is always made at the lowest salary and a promotion to the next higher class requires at least three years' service.

These departmental professors are the chiefs of the agricultural service in their departments. They represent the administration of agriculture and are under the direct authority of the prefect of the department and of the inspector of agriculture. They have under their direction the "special" professors of the department, to whom, however, they leave the greatest possible latitude and initiative.

It is the duty of the departmental professor to give a two-years' course of instruction in agriculture at the normal primary school for teachers established in his department, and if necessary in other establishments of public instruction; to deliver at least 26 lectures upon agricultural subjects each year at meetings of farmers, and to disseminate by lectures and other means the scientific discoveries and practical methods which tend toward the intelligent and profitable management of the soil. It is also their duty to stand in close relation to the agricultural societies and syndicates in order that they may act as advisers to those interested in agricultural questions, and to come in contact as freely as possible with the rural classes. In this way they are expected to keep themselves posted on the current wishes and needs of the agricultural people. Each departmental professor is required to make report at the close of each year to the prefect of the department in which he resides, to be transmitted to the minister of agriculture and commerce of the Republic.

There is another feature of the work of the departmental professor that has been of great value in enforcing his teachings, both in the normal schools and in the meetings in the rural districts which he addresses. It is the system of practical demonstration that he conducts in fields selected in various suitable locations in which are shown the effects of various manures, modes of culture, and varieties of seeds upon crop production. It is stated that in 1894 there were over 3,300 such fields being conducted for illustration purposes throughout France.

SPECIAL PROFESSORS OF AGRICULTURE.

The duties of the special professors are in most respects similar to those of the departmental professors, with whom they are expected to cooperate. They are expected to teach agriculture in the superior primary schools, and also to deliver at least 12 lectures annually at rural meetings of agricultural people, the object being to make known to practical farmers the improved methods in use in the management of domestic animals, and which lead to a more profitable production of farm crops. Their salaries vary from $450 to $580 per year.

The items in the law relating to departmental and communal instruction in agriculture, and in the decree by the President of the Republic, relative to the departmental and special professors of agriculture, give with great particularity the details of the system of itinerant instruction in agriculture in operation in France. In order that those who are interested in the study of this system may have reliable information at hand, the law and decree are given in full.

Law of June 16, 1879, relative to the departmental and communal instruction in agriculture in France.

Article 1. Within a period of six years following the promulgation of the present law a chair of agriculture shall be established, in accordance with the following rules, in the departments not already possessing this institution.

The programme of instruction shall include all branches of agricultural industry, and more specially the study of the methods of cultivation of the region.

Art. 2. The departmental professors of agriculture will be chosen by competition, and upon the report of a jury selected by the minister of agriculture and commerce, and constituted in the following manner:

(1) The inspector-general of agriculture, president;

(2) The inspector of the academy;

(3) A professor of chemistry or physics;

(4) A professor of natural sciences.

These two last examiners will be chosen from the teaching staff of the agricultural institute or of an agricultural school, and, in their default or absence, they must belong to the State university.

(5) A professor of the veterinary college or of the nearest school of medicine, or a certificated veterinary surgeon.

(6) Three agriculturists, chosen by the departmental commission from among the members of the agricultural associations of the department, who are nominated by each of these associations.

(7). A councilor-general, designated by his colleagues.

The professors of agriculture will be appointed by an order concerted between the minister of agriculture and commerce and the minister of public instruction and fine arts.

Art. 3. The competition will take place at the chief town of the department; the examination will turn upon the general principles of agriculture, vine growing, arboriculture and horticulture, and on the sciences in their application to the situation, the productions, and the climate of the department.

Art. 4. The programme of the competition will be decided upon by the ministers of agriculture and public instruction, in accordance with the advice of the agricultural associations and the general council of the department.

Art. 5. The candidates must (in order to be admitted to the competition) be Frenchmen, and be at least 25 years of age. If they can produce the diploma of bachelor of science, or that of the agricultural institute, or of an agricultural school, a certain number of marks fixed by the minister of agriculture will be allowed to them.

Art. 6. The professors of agriculture must give lessons at the normal primary school (near to which they ought to reside, if this is possible), also at other establishments of public instruction where they are required, and they must give agricultural lectures in the different communes of the department to the teachers and agriculturists of the region.

Art. 7. The salary of the departmental professor of agriculture will be paid from the funds of the budget of the ministry of agriculture and from those of the budget of the ministry of public instruction.

The expenses of the journeys will be chargeable to the department.

Art. 8. The functions, as also the dismissal, of the departmental professors of agriculture will be determined by public administrative enactment.

The order in question will determine the salary of the departmental professors.

It will also fix the minimum expenses of the journeys of the professors of agriculture with reference to each department in accordance with the advice of the general council.

ART. 9. The professors of agriculture already actually employed, whether they have been nominated after competition or not, will not have to undergo the test of a new competition.

ART. 10. Three years after the complete organization of agricultural instruction in normal primary schools elementary instruction in agriculture will be included in the obligatory subjects of primary education.

In those departments, however, in which instruction in agriculture has already been organized at the normal primary school for more than three years, the departmental council of public instruction may decide whether this same instruction shall be compulsory in all the primary schools of the department.

The programmes of this instruction in each department will be drawn up after consultation with the departmental council of public instruction.

Decree of June 9, 1880, relative to the departmental professors of agriculture in France.

ARTICLE 1. Each competition to be opened in a department for the appointment to the functions of departmental professor of agriculture is to be announced three months beforehand by the insertion of a notice in the official journal.

Within two months, dating from the insertion of this notice, the candidates must address their demand to be admitted to the competition either to the ministry of agriculture and commerce, or to the prefecture of the department where they reside. With their demand they must send in a certificate of birth, a certificate of good conduct and behavior, and a statement setting forth their antecedents, their titles, and their scientific works.

ART. 2. The minister of agriculture and commerce prepares the list of candidates admitted to the competition.

This list is definitely decided upon in concert with the minister of public instruction and fine arts.

ART. 3. The jury is to meet on the day fixed by the order of the minister of agriculture and commerce, by whom it has been constituted, to examine the papers of the candidates and to settle the order of the examination tests.

ART. 4. The competition comprises three sorts of tests:

A written test, oral tests, and practical tests.

The programme of the competition, drawn up as set forth in article 4 of the law of the 16th of June, 1879, is published in the official journal, with the notice prescribed in article 1 of the present order.

ART. 5. The official report of the operations of the jury is to be addressed, together with the papers of the candidates, to the minister of agriculture and commerce, who transmits them to his colleague, the minister of education and fine arts, together with a scheme for the issue of the appointments.

The original of the scheme must be deposited at the ministry of agriculture and commerce.

ART. 6. The departmental professors of agriculture can be dismissed by either one of the two ministers, after notice to his colleague.

The decision leads to the complete dismissal of the functionary.

ART. 7. The salary of the departmental professors of agriculture is paid as follows: Half from the funds of the budget of the ministry of agriculture and commerce, and half from that of education and fine arts.

ART. 8. The departmental professors of agriculture are divided into four classes, the salaries of which are fixed as follows:

First class	$871.20
Second class	774.40
Third class	677.60
Fourth class	580.80

The first nomination is always to the fourth class.

The transfer from one class to that immediately above it can only take place after three years' service at least.

This promotion is decided upon by the two ministers (of agriculture and commerce and of education and fine arts).

ART. 9. The costs of the journeys of the departmental professor of agriculture, to be charged to the department by article 7 of the law of June 16, 1879, are fixed in each department by the general council; but they must not be less than the sum of $96.80 annually.

This expenditure must not be deducted from the funds appropriated to the service of primary education.

ART. 10. The departmental professors of agriculture are especially appointed for the department in which they have competed. They may, however, be called upon, in consequence of an order arranged between the two ministers, to remove into another department in which the conditions of agriculture are analogous.

ART. 11. Departmental professors of agriculture, who accept elective appointments in the departments to which they have been nominated, are considered to have resigned.

ART. 12. The duties of the departmental professor of agriculture are comprised in the conditions set forth in the following articles:

(1) Agricultural instruction in the normal primary school and, if necessary, in the other establishments of public instruction.

(2) Agricultural lectures in the country districts.

(3) Works or investigations with which he may be intrusted by the prefect of the department or by the minister of agriculture and commerce.

ART. 13. The programme of the course given at the normal primary school is promulgated by the minister of education and fine arts, the superior council of public instruction approving, after consultation with the minister of agriculture and commerce.

This course is to be followed by pupils of the second and third years. It is based on two lessons a week, supplemented by a practical exercise or an agricultural excursion.

ART. 14. The agricultural lectures in the country are to be delivered according to a programme decided upon each year by the minister of agriculture and commerce. There are to be at least twenty-six in each year. The localities in which they are to take place will be decided upon by the prefect.

ART. 15. A report of these lectures is to be addressed by the professor at the end of each year to the prefect of the department, to be transmitted to the minister of agriculture and commerce, and also to the general council of the department.

ART. 16. Independently of the duties specified in the preceding articles, the departmental professor of agriculture is to furnish to the prefect all possible information respecting the agriculture of his department.

ART. 17. The ministers of agriculture and commerce and of education and fine arts are charged, each one as far as he is personally concerned, with the execution of this decree.

HUNGARY.

Hungary has an area of 125,039 square miles of territory, and had a population in 1900 of 19,254,559, about 75 per cent of whom are engaged in agriculture. Many of the estates of the nobles embrace as much as 500,000 acres; holdings by the peasants range from one-half acre to more than 100 acres. In 1895 it was estimated that 48.5 per cent of the arable land was included in holdings of from 5 to 100 acres. The small farmers, for purposes of cultivation, add to the area that they own in fee portions of adjoining estates, which they lease, and for the use of which a money rental is paid.

In Hungary the State has assumed responsibility for the development of her agriculture to a greater extent than in any other European country. The State has organized, controls, and supports a system of colleges, schools, demonstration and research stations for instruction in agriculture that is remarkably complete.

There is, first of all, the agricultural college at Magyar-Óvaŕ, in which higher teaching in agriculture is given. Then there are 4 middle schools or agricultural colleges very finely equipped. There are 21 tillage schools, a veterinary college, an arboricultural college, a dairy high school, a horticultural college, a poultry-farming school, a bee-farming school, a meadow-culture school, 8 schools for vine dressers, 5 State stock farms, an agricultural museum, 80 model demonstration farms, and a large number of winter agricultural schools, attended in 1901 by about 300,000 persons, all of them either cultivators of farms, landed proprietors, or teachers.

The "tillage" or "farming" schools are intended for the education of the peasantry in a way to qualify them as managers of small farms, or as foremen and head laborers on large estates. The course is of two years' duration, and is intensely practical in character.

The five State farms embrace 163,000 acres of land, and have yielded an annual revenue to the Government of almost $1,500,000. They are devoted chiefly to the breeding and rearing of pure-bred horses and cattle. Each spring, stallions are sent out under the care of soldiers and distributed so as to be available for service in all communities. The number of registered stallions in 1901 owned by the Government was 3,100. There is also a large number of well-bred bulls sold from the stock farms to local communities, the purchase money being raised by a tax levied by the parish council. In 1901, 3,428 bulls were distributed and sold.

The poultry farm is managed in much the same manner as the stock farms referred to. The roosters are exchanged with the peasants for common fowls, as well as are eggs of pure-bred poultry for hatching purposes. Over 7,000 roosters were exchanged by the State farms with the peasants in a single year.

The eighty model farms are conducted chiefly for purposes of demonstration, and are either rented or purchased by the Government. In all cases an expert is placed in charge of each farm, who is under the direction of the agricultural minister, and who cultivates such crops only as serve to enlighten the citizens of the particular community in which the farm is located as to the adaptability of that particular crop to their locality. The farms are only used for a few years, when they are sold or surrendered, and the stations are moved to other communities. In this way the people in all sections of the country are made acquainted with new and improved methods in agriculture through practical demonstrations.

ITINERANT LECTURERS.

In addition to the foregoing elaborate system of instruction in agriculture, there is in operation a system of institutes not unlike those of the United States. During the year 1903–4, 300 agricultural meetings of this character were held in Hungary, at which there were in attendance over 24,000 persons. The meetings were addressed by a corps of 635 lecturers.

The lecture force is divided into two classes. One class is composed of what are known as "itinerant lecturers," and the other as "amateurs." The "itinerant lecturers" are appointed by the agricultural minister. Their duties are to travel through the rural districts and deliver lectures on agricultural matters, making known the newest results of experience and the most approved methods for the improvement of agriculture. These lecturers are employed by the year, and are paid salaries ranging from $650 to $750, with from $75 to $200 additional for house rent and $200 annually for traveling expenses.

The "amateurs" are chosen from time to time by the local agricultural societies from among experts and capable landlords, farmers, college men, and county and State officials. They lecture only during the winter and receive but a small compensation in addition to their traveling expenses. These "amateurs" deal more particularly with the practical side of agriculture, and are selected with special regard to the local conditions that exist in the several communities.

Many of the lectures are given on Sundays and holidays. This is the usual rule when daytime meetings are held. During week days the lectures are given in the evenings in town halls and schoolhouses. At times under special circumstances, when the attendance is unusually large, meetings are held in the open air.

Many of the lectures are published by the agricultural minister, and distributed free among those in attendance at the institute meetings. The organization of the courses in the winter schools, together with the selection of the dates and places of the meetings, is intrusted to the local agricultural societies, who are required to present a detailed plan of the course two or three months in advance to the agricultural minister.

In 1903–4 over 2,400 lectures on agricultural subjects were delivered in farmers' institute meetings.

ITALY.

During the year 1903 about ninety "conferences" of farmers, similar to institute meetings, were held in Italy.

The teachers who give instruction in the conferences are chosen from among the doctors of agrarian science, graduates of the higher agricultural schools of the Kingdom, after a competitive examination held by the administration authorities in the several provinces. The selections, however, must subsequently be approved by the minister of agriculture of the Kingdom.

Applicants for the itinerant chair of agriculture must submit proof of having spent three years in the attainment of the degree of doctor of agricultural science, during which time proper training must have been had in the application of scientific truth to practical agriculture. Preference is given to those who have acquired their training in applied science in a school or institute of agriculture, or in connection with an agricultural experiment station. The applicant must also have undergone an apprenticeship of not less than one year on an agricultural estate. The examination consists of a written test, a reading or conference, a discussion, and a practical test in the field.

The lecturers are officially known as directors of itinerant chairs of agriculture, and have their office addresses in the capitals of the provinces or districts in which they severally reside. They are employed during the entire year, and it is their duty to hold meetings in the towns, villages, and country communities of the province or district to which they are assigned.

The functions of the itinerant chair of agriculture are: To hold conferences of a practical nature in a simple form regarding the various phases of agronomy, animal industry, wine, oil making, etc.; to reply to oral and written questions from private individuals and societies regarding agricultural matters; to institute experimental fields, publish results obtained in such experiments, and assume the direction of such fields; to collect statistics regarding agricultural production in the region covered by the chair; to maintain vigilance against the invasion of parasitic insects and infectious diseases of plants and animals, and to publish circulars in simple language containing practical advice to farmers. They aim also to develop organization among farmers; to establish cooperative societies for the production and sale of agricultural products; to experiment with agricultural machinery; to introduce new plants and better methods of cultivation throughout the provinces; to devise useful plans for the amelioration of agricultural conditions in general, and by verbal consultation and written communications to give expert advice to those who desire it.

Their salaries range from $700 to $1,000 per year. Three-fifths of the expense of maintaining itinerant chairs is borne by the province or district and two-fifths by the minister of agriculture.

The total expense for the year 1903 was about $150,000, of which about $42,500 was from Government grant through the minister of agriculture and the balance by contributions by the provinces and districts and by the local agricultural organizations.

NETHERLANDS.

Each of the eleven provinces of the Netherlands has an agricultural society. There is also in the Kingdom a central council of agriculture, composed of representatives elected by the various provincial societies. This central council, which meets periodically at The Hague, endeavors not only to improve the agriculture of the country directly by offering suggestions to the subordinate provincial societies, but also acts as the adviser in agricultural affairs of the ministry under whose direction the department of agriculture is placed. The wisdom and influence of this central council are recognized by the State to the extent that no important measure affecting agriculture is undertaken by the ministry without the advice and consent of the council.

In each of the provinces there is also a State professor of agriculture, whose duties are to deliver lectures on agriculture, to inspect and direct the State experiment stations, of which there are five; to inspect the winter agricultural courses, and to provide instruction for primary school-teachers who desire to obtain agricultural certificates.

There are two kinds of agricultural winter schools. One is local or permanent, and is maintained by the provincial agricultural society, aided by the State; the other is migratory. The permanent schools send out itinerant teachers, who give courses of instruction to farmers, who meet and organize classes in the various centers much after the manner practiced in Belgium. The courses of study for these movable schools are arranged with a view to the presentation of a single topic and for continuing its discussion until a reasonably thorough acquaintance with the subject has been had by the members of the class. The courses are also sufficiently numerous to embrace the most important subjects of agricultural operation, a separate course and school being organized for each.

The experiment fields and gardens which the Government has established all over the country, and to which reference has been made, are utilized by the itinerant teachers in their instruction work, who visit them frequently with their classes and observe the results of the various experiments as they develop.

These movable schools of Holland have been found to be a most effective means for conveying instruction in agriculture to the homes of the people. They bring the experience and observation of men of large acquaintance with agricultural affairs to the attention and aid of those whose occupation and surroundings have limited their knowledge of farming largely to what has been practiced in their own communities.

Through the aid supplied by the local experiment fields and gardens the itinerant teachers are able also to demonstrate in an ocular, and therefore most convincing way, the truth of many of the theories that they present and to show their adaptability to the conditions that exist in that particular community.

PRUSSIA.

The methods pursued in imparting agricultural instruction in Prussia are substantially those in use in the other German States. The Prussian system is therefore presented as typical of work of this character throughout the Empire.

In reply to an inquiry respecting the system in use in Prussia corresponding to the farmers' institutes of the United States, the following statement was received from the minister of agriculture and forestry of Prussia:

> The different provinces of the Kingdom of Prussia, twelve in number, are provided with chambers of agriculture, established by law as bodies representing the agricultural interests of the province. Under the auspices of these institutions courses of lectures for practical farmers are given each year. The course, as a rule, lasts for from two to five days. The lectures are delivered either where the chambers are located or at some other convenient and accessible place.
>
> The instruction is free to all farmers except that in some rare instances a nominal tuition is required. The lectures are delivered by professors of neighboring schools, by leading practical agriculturists, or by officers of the chamber. The subject treated in the lecture is usually discussed before adjournment.
>
> The preparation and selection of the topics, as well as the direction and carrying out of the course, is entirely in the hands of the chamber of agriculture, and the money paid for the lectures is drawn from their appropriation. The fee for a one-hour discourse is usually from 50 to 100 marks [$12 to $24].
>
> The attendance varies considerably in the different provinces, but an average attendance upon a course may be assumed to be about 100. These courses for practical farmers have proved a success and are considered as a very valuable complement to the activities of the different grades of agricultural schools.

In a report on agricultural education in north Germany by Mr. H. M. Jenkins, secretary of the Royal Agricultural Society of England, the system of agricultural education in north Germany by means of itinerant lecturers is very fully outlined. He states that:

> They travel through the provinces and discuss the more important agricultural questions at assemblies of farmers convoked for the purpose. After the lecture, follow discussions and an exchange of views and experiences. The lecturers are usually teachers in the winter agricultural schools who give instruction in these schools in the winter and take up the work of traveling lecturers [Wander-Lehrer] during the summer.

The relation existing between the winter agricultural schools and the summer courses of lectures is such that for the proper understanding of their respective functions it is necessary that the character and purpose of each of these classes of schools should be outlined.

The object and character of the winter schools are stated by Mr. Jenkins as follows:

> (*a*) The object of the agricultural winter schools is to continue the general education of young men who have left the elementary schools, as well as to give them instruction in technical subjects bearing upon agriculture, and in agriculture itself. Only those young men are received into these schools whose final certificates from the elementary schools show that they are in a position to profit by the instruction which is given in the winter schools.
>
> (*b*) The instruction is arranged for two winter courses in such a manner that in the first course the general education is continued and the groundwork for the second course is laid. In the second winter the instruction given is chiefly technical. Thirty-three hours in each week are devoted to the lessons, and the transfer of pupils from the second to the first class depends upon the manner in which they pass their examination at the end of the first winter course.
>
> (*c*) The instruction begins on the 3d or 4th of November in each year, and concludes with a public examination at the end of the following March. During the remaining seven months the pupils are employed on the farms of their parents or upon other agricultural holdings, and then the director of the school acts as a traveling lecturer and adviser within the district for which the school has been organized.

The following detailed plan of the studies will give a sufficiently accurate idea of the scope of the instruction furnished at these schools:

FIRST WINTER.

	Hours per week.
A.—Natural science and agriculture:	
1. Elementary agricultural chemistry (inorganic)	7
2. Mineralogy and soils	
3. Zoology, especially of domesticated animals	7
4. (*a*) Cattle breeding and rearing	
(*b*) Dairying	
5. Physics (mechanics and electricity)	3
6. Farm management, bookkeeping, etc	5
B.—General education:	
7. German language	5
8. Arithmetic, land surveying, and leveling	4
9. Drawing	2
	33

SECOND WINTER.

A.—Natural science and agriculture:	
1. Elementary agricultural chemistry (organic)	7
2. (*a*) Botany and vegetable physiology (general)	7
(*b*) Agricultural botany and vegetable physiology, including plant diseases, irrigation, and gardening	
3. Physics and meteorology (including light and heat)	3
4. Farm management (capital, labor, and organization)	5
B.—General education:	
5. German language	5
6. Arithmetic, land surveying, and leveling	4
7. Drawing	2
	33

The ages of the pupils at the winter schools vary from 15 to 30 years, and the school is divided into two classes, the lower of which is regarded as preparatory to the higher in the following winter. In one school referred to by Mr. Jenkins as typical there was the director, who was also the itinerant lecturer of the district, and seven assistant teachers, all employed in teaching about forty pupils. The salary of the director is $750 per year.

The following set of printed instructions issued by the president of the Agricultural Society of Rhenish Prussia gives in detail the duties of the director of the winter school, and also his work as agricultural itinerant lecturer:

During the five winter months, from the first of November to the first of April, the director is to give instruction in his school in natural science and in agriculture. The remaining seven months he is to spend as itinerant lecturer in his school district.

His services belong entirely to the society, and he is not permitted to undertake any other professional occupation.

In his double capacity of director of the school and traveling lecturer he has to cooperate not only with the several branches of the Agricultural Society of Rhenish Prussia, but also with the agricultural authorities and the school inspectors of his district, and to use every means to specially interest the latter in the school intrusted to his care.

He is expected to visit the burgomasters, the chief officials of the place, the clergy, the schoolmasters, and the principal landowners of his district, with a view of interesting them likewise in the school.

THE DIRECTOR AS AGRICULTURAL ITINERANT LECTURER.

During the months in which there is no school the director of the winter school spends his time as agricultural itinerant lecturer in his school district.

(1) After having agreed with the president of the society and with the directors of the several divisions of his school district, he is to travel through the said district to deliver his lectures, to study the existing agricultural conditions, to point out defects to those concerned, to explain their causes, and to specify the ways and means for their improvement.

He is to use his influence toward promoting the execution of such improvements and to see that they are carried out.

He has to pay special attention to the aims which the individual farmers have each in view and to the arrangements made for the attainment of this end, and to note whether aim and arrangement are suited to the circumstances. Further, he must direct his attention to the animals, their breeding and use, the number and fitness of the male animals, the manner of feeding, the stabling and the management of the manure heaps, the condition and extent of the arable land and pasturage in proportion to the live stock, the implements employed and desirable additions, how far artificial manure is used, the draft animals, whether the available capital is sufficient, purchase and rent value per acre according to the quality of the soil, drainage, footpaths, succession of crops, orchard management, horticulture, market gardening, winter employment, and piecework.

He must encourage parents to send their sons to the winter schools. During his journeys he must endeavor to visit young men who, having gone through their course of studies, have returned home, and encourage them in their work.

(2) As in many instances individual means and powers are insufficient, he must point out to the small proprietors the advantages to be gained by intelligent cooperation, and must give all possible information about the establishment of loan societies, cooperative food-supply associations, societies for the insurance of live stock, vine dressers' societies, agricultural clubs, etc.; he must point out how such institutions can and must be created by the farmers themselves and the advantages that may accrue from them.

(3) He must assist in controlling the proper application and observance of the conditions upon which the subsidies paid by the State and the society are granted, and for this purpose he will receive a list of the same from the secretary-general and must state the result in his yearly report.

He must explain to the agricultural population the objects and usefulness of the institution, and the protection and advantage it offers, such as laboratories for chemical analyses and experiments, stations where bulls, boars, and stallions are to be found, cattle shows and prizes, institutions for the trial of machines and implements, agricultural clubs, exhibitions, etc., and encourage their participation in these organizations.

(4) He must give theoretical and practical courses of instruction at the proper season on beehives and the proper rearing of bees, and on fruit trees and vines and their treatment, and also on agricultural bookkeeping on a selected farm. He must appoint a stated time for these lectures and issue a public invitation to all to attend them.

(5) In his annual or in separate reports he is to make suggestions as to the means which should be adopted on the part of the society for encouraging such improvements as he shall have found to be necessary.

(6) He must visit the existing agricultural schools and improvement clubs on his journeys and register and report their condition, hold conferences with the directors, and use his influence toward the erection of new clubs.

(7) He has to keep a diary of everything important that he has observed and done during his journeys, and include a statement of the same in his report to the president of the society.

The itinerant lecturer is to have a month's holiday from the 15th of July to the 15th of August.

RUSSIA.

A statement of the methods employed in reaching the rural population of Russia with agricultural information has been furnished by the Russian minister of agriculture in the following communication:

Agricultural information is disseminated among the farming population of Russia by means of special lectures upon the most important local problems of each locality, and by means of systematic courses of instruction in the schools, including full details in concise form, upon some one branch of agricultural science. Recently information concerning agricultural subjects has been spread among the farming population by means of itinerant teachers. By this means the farmers are directly met and aided, and the instructors are also enabled to unite with their technical knowledge of agricultural science a practical acquaintance and understanding of the agricultural and social conditions and needs that exist among the people to whom their instruction is addressed. Such an arrangement has made possible an unusually wide distribution of agricultural information.

In these movable courses of lectures the attending farmers acquaint themselves with recent investigations concerning the various branches of agricultural science, and a similar fund of information is made available through courses given by the teachers to pupils in the primary agricultural schools of the various communities.

As a rule, the themes selected by the lecturers and teachers are such as are calculated to exert an influence in the further agricultural development of the locality concerned. The persons concerned in giving these lectures and courses of instruction are agronomists, teachers in agricultural institutions, agricultural inspectors, specialists, and instructors in agricultural branches in various educational institutions. Systematic courses of lectures and instruction are given in practical gardening, raising field crops, etc. The teachers and lecturers receive for their work suitable compensation from the department of agriculture.

Agricultural courses for common school pupils were organized in 1903. At this time a special committee was appointed by the Government for the purpose of preparing a programme of courses and instruction in agriculture, together with a list of themes to be discussed, books, charts, and other material to assist in instruction. During that year 20 educational institutions offered courses in agriculture, and 450 persons were enrolled as students in these courses.

The general administration of "outside" or "itinerant" class work in agricultural subjects is a function of the department of agriculture in St. Petersburg.

SWEDEN.

Provision for imparting technical instruction in agriculture in Sweden, 75 per cent of whose population is engaged in this occupation, is made through schools in the several districts organized and equipped for the special purpose. The establishing of a large number of stationary schools of agriculture for adults in preference to the itinerant system seems to have been decided upon after a careful examination of this kind of instruction in other countries, which accounts for the absence of the movable school.

Three distinct classes of high schools have been organized and are in operation in Sweden: People's high schools for men; people's high schools for women, and high schools for peasants. The first of these, or the people's high schools for men, was opened in 1868. As the title suggests, they are intended for men, the average age at which pupils enter being 21 or 22 years, although the minimum age for admission is 18.

The people's high schools at first were supported entirely by private subscription, but later were aided by the Government with grants not exceeding $800 for schools having a one-year course, and not more than $1,350 for schools having a two-year course, the latter sum being given on condition that at least one-fourth of the pupils of the first-year course come back the second year.

The people's high schools are all located in the country, and their popularity is evidenced by their number, which in 1903 had reached 872. The lectures and classes of these schools occupy about twenty-two weeks, the school terms being arranged to come between the months of November and April, a season of comparative cessation of field work.

Each course takes for its completion 955 hours of recitation or lectures.

The subjects taught in the school at Hvilan, as reported by Mr. J. V. Jonsson, head master of the people's high school at Kafvesta, are:

Swedish, 120 hours; Scandinavian history, 80 hours; general history and geography, 100 hours; history of literature, 40 hours; national economy, 20 hours; political and municipal science, 50 hours; physics, botany, zoology, and geology, 45 hours; agricultural chemistry, 50 hours; anatomy and hygiene, 10 hours; geometry, 20 hours; arithmetic, 100 hours; bookkeeping and practical training, 70 hours; drawing and architecture, 90 hours, and gymnastics, 100 hours.

The course, it will be seen, is constructed with a view to affording information upon such topics as enter into a general education.

It was found after several years of trial that the pupils who entered the people's high schools were for the most part sons of farmers and were themselves farmers. It soon became evident not only that one winter was too short a period in which to give the training needed by these young men, but also that a more technical course of study was needed to equip them for their work. Accordingly, in 1882 a commission was appointed by the King to prepare a scheme for the organization of agricultural instruction in the Kingdom, which resulted in the establishment of a second class of schools, called high schools for peasants. These schools were intended to give theoretical instruction in agriculture to young men over 18 years of age who have gone through the people's high school. For admission to this school they must also have prosecuted farming for at least one year.

The high schools for peasants are with a few exceptions annexed to the people's high schools, and are under the immediate control of the agricultural department. They are aided by the State, but are required at the same time to provide an equal sum from fees and other local sources. The course extends over a period of 20 months.

The practical training of the students is usually accomplished through the school authorities finding positions for them as laboring pupils on some large estate, the proprietor supplying them with board and lodging and a small compensation for clothes. Sometimes they secure positions as under stewards on plantations.

The courses of study in these schools are chiefly agricultural. The subjects given in one at Kafvesta in 1903 were:

Physics, 24 hours; chemistry, 38 hours; botany, 29 hours; zoology, 26 hours; geology, 40 hours; science of agricultural practice, 84 hours; agricultural economy, 12 hours; care of domestic animals, 51 hours; veterinary science, 17 hours; dairying, 10 hours; forestry, 8 hours; building construction, 8 hours; geometrical drawing, 58 hours; surveying, 71 hours; geometry, 20 hours; arithmetic, 60 hours; Swedish, 60 hours; municipal expenses, 19 hours; composition, 30 hours; debates, 36 hours; bookkeeping, 60 hours; singing, 40 hours, and gymnastics, 70 hours; making a total of 871 hours.

These schools, first established in 1886, have increased until in 1903 they numbered 239. There are 30 districts in Sweden. In all but seven people's high schools have been organized, and the effort has been to have them so distributed and sufficiently numerous as to make them easily accessible to young men in all parts of the Kingdom.

It is proposed to add "special" courses for small farmers who can not attend school for a whole winter, but who would be greatly benefited by having the opportunity to enter upon a brief course of study to last only a few weeks. In connection with these special courses and as a part of the system of instruction small farms of only a few acres are to be attached to the schools as demonstration farms. The purpose is to conduct them not for experimentation, but as illustrations or demonstrations of the best methods of successful agricultural production. These "model" farms serve to show how a small farm can be successfully managed, and thus encourage the students to purchase and conduct similar farms for themselves.

High schools for women were undertaken in 1869 as separate institutions, but owing to the brief period, only two or three months in the year during which they could be in operation, the project failed. Later these schools were organized in connection with the high schools for peasants and the people's high schools, as a summer course, beginning at the close of the men's winter courses and extending over about three months, May, June, and July. The studies were of a general character during the first year, supplemented by courses in practice, such as cookery, canning, weaving, gardening, poultry keeping, etc. This practical course is made a special feature in the work of the second year.

In 1903 636 high schools for women had been established and were in successful operation.

The system, therefore, that has been adopted in Sweden, providing for the instruction of adults in agriculture, consists in establishing a large number of high schools in which agriculture is taught, and which are in session for men for five months and for women three months, the men attending in the winter during the period of suspension of farming operations and the women during the spring and early summer after the men's sessions have ended.

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Farmers' Institute Lecture No. 3. Syllabus of Illustrated Lecture on Acid Soils, accompanied with 53 lantern slides. By H. J. Wheeler. Pp. 28. 1904.

Farmers' Institute Lecture No. 4. Syllabus of Illustrated Lecture on Profitable Cattle Feeding, accompanied with 45 lantern slides. By F. B. Mumford. Pp. 21. 1905.

Farmers' Institute Lecture No. 5. Syllabus of Illustrated Lecture on Silage and Silo Construction for the South, accompanied with 50 lantern slides. By A. M. Soule. Pp. 31. 1905.

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 164.

A. C. TRUE, Director.

PROCEEDINGS

OF THE

NINETEENTH ANNUAL CONVENTION

OF THE

ASSOCIATION OF AMERICAN AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS,

HELD AT

WASHINGTON, D. C., NOVEMBER 14-16, 1905.

EDITED BY

A. C. TRUE and W. H. BEAL, for the Office of Experiment Stations,

AND

H. C. WHITE, for the Executive Committee of the Association.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

THE AGRICULTURAL COLLEGES.

Alabama—*Auburn:* Charles C. Thach.[a] *Normal:* Wm. H. Councill.[a] *Tuskegee:* Booker T. Washington.[b]

Arizona—*Tucson:* Kendrick C. Babcock.[a]

Arkansas—*Fayetteville:* J. N. Tillman.[a]

California—*Berkeley:* Benjamin Ide Wheeler.[a]

Colorado—*Fort Collins:* Barton O. Aylesworth.[a]

Connecticut—*Storrs:* R. W. Stimson.[a]

Delaware—*Newark:* Geo. A. Harter.[a] *Dover:* W. C. Jason.[a]

Florida—*Lake City:* Andrew Sledd.[a] *Tallahassee:* Nathan B. Young.[a]

Georgia—*Athens:* H. C. White.[a] *Savannah:* R. R. Wright.[a]

Idaho—*Moscow:* J. A. MacLean.[a]

Illinois—*Urbana:* E. J. James.[a]

Indiana—*Lafayette:* Winthrop Ellsworth Stone.[a]

Iowa—*Ames:* Albert Boynton Storms.[a]

Kansas—*Manhattan:* Ernest R. Nichols.[a]

Kentucky—*Lexington:* J. K. Patterson.[a] *Frankfort:* James S. Hathaway.[a]

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Maine—*Orono:* George Emery Fellows.[a]

Maryland—*College Park:* R. W. Silvester.[a] *Princess Anne:* Frank Trigg.[b]

Massachusetts—*Amherst:* Wm. P. Brooks.[c]

Michigan—*Agricultural College:* J. L. Snyder.[a]

Minnesota—*St. Anthony Park, St. Paul:* Cyrus Northrop.[a]

Mississippi—*Agricultural College:* J. C. Hardy.[a] *Lorman:* L. J. Rowan.[a]

Missouri—*Columbia:* R. H. Jesse.[c] *Jefferson City:* B. F. Allen.[a]

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Nebraska—*Lincoln:* E. Benjamin Andrews.[d]

Nevada—*Reno:* N. E. Wilson.[c]

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New Jersey—*New Brunswick:* W. H. S. Demarest.[a]

New Mexico—*Agricultural College:* Luther Foster.[a]

New York—*Ithaca:* Jacob Gould Schurman.[a]

North Carolina—*West Raleigh:* G. T. Winston.[a] *Greensboro:* James B. Dudley.[a]

North Dakota—*Agricultural College:* J. H. Worst.[a]

Ohio—*Columbus:* William Oxley Thompson.[a]

Oklahoma—*Stillwater:* Angelo C. Scott.[a] *Langston:* Inman E. Page.[a]

Oregon—*Corvallis:* Thos. M. Gatch.[a]

Pennsylvania—*State College:* George W. Atherton.[a]

Rhode Island—*Kingston:* Kenyon L. Butterfield.[a]

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South Dakota—*Brookings:* R. L. Slagle.[a]

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Vermont—*Burlington:* M. H. Buckham.[a]

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West Virginia—*Morgantown:* D. B. Purinton.[a] *Institute:* J. McHenry Jones.[a]

Wisconsin—*Madison:* Chas. Richard Van Hise.[a]

Wyoming—*Laramie:* Frederick M. Tisdel.[a]

---

[a] President. [b] Principal. [c] Acting president. [d] Chancellor.

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 164.

A. C. TRUE, Director.

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PROCEEDINGS

OF THE

NINETEENTH ANNUAL CONVENTION

OF THE

ASSOCIATION OF AMERICAN AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS,

HELD AT

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A. C. TRUE and W. H. BEAL, for the Office of Experiment Stations,

AND

H. C. WHITE, for the Executive Committee of the Association.

1862 1889

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

THE OFFICE OF EXPERIMENT STATIONS.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., January 15, 1906.

Sir: I have the honor to transmit herewith for publication Bulletin No. 164 of this Office, containing the proceedings of the nineteenth annual convention of the Association of American Agricultural Colleges and Experiment Stations held at Washington, D. C., November 14–16, 1905.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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Secretary and Treasurer.

J. L. Hills, of Vermont.

Bibliographer.

A. C. True, of Washington, D. C.

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C. R. Van Hise, of Wisconsin; H. C. Price, of Ohio, *Programme Committee.*

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H. P. Armsby, of Pennsylvania; C. F. Curtiss, of Iowa; M. A. Scovell, of Kentucky, *Programme Committee.*

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Experiment Station Organization and Policy.

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LIST OF DELEGATES AND VISITORS IN ATTENDANCE.

Alabama: C. A. Cary, J. F. Duggar, R. S. Mackintosh, C. C. Thach, C. C. Thach, jr.

Arizona: K. C. Babcock.

Arkansas: A. H. Purdue, H. Stroup, J. N. Tillman, W. G. Vincenheller.

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Wisconsin: E. H. Farrington, G. N. Knapp, E. P. Sandsten, H. C. Taylor, C. R. Van Hise.

Wyoming: B. C. Buffum, F. M. Tisdel.

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Bureau of Education: L. A. Kalbach.

Canada: G. C. Creelman, H. H. Miller, J. C. Readey.

CONSTITUTION OF THE ASSOCIATION.

NAME.

This association shall be called the Association of American Agricultural Colleges and Experiment Stations.

OBJECT.

The object of this association shall be the consideration and discussion of all questions pertaining to the successful progress and administration of the colleges and stations included in the association, and to secure to that end mutual cooperation.

MEMBERSHIP.

(1) Every college established under the act of Congress approved July 2, 1862, or receiving the benefits of the act of Congress approved August 30, 1890, and every agricultural experiment station established under State or Congressional authority, the Bureau of Education of the Department of the Interior, the Department of Agriculture, and the Office of Experiment Stations of the last-named Department shall be eligible to membership in this association.

(2) Any institution a member of the association in full standing may send any number of delegates to the meetings of the association. The same delegate may represent both a college and a station, but shall vote in only one section and shall cast only one vote in general sessions. Other delegates may be designated by any institution to represent it in specified divisions of the sections of the association, but such delegates shall vote only in such divisions, and no institution shall be allowed more than one vote in any sectional meeting.

(3) Delegates from other institutions engaged in educational or experimental work in the interest of agriculture or mechanic arts may, by a majority vote, be admitted to conventions of the association, with all privileges except the right to vote.

(4) In like manner, any person engaged or directly interested in agriculture or mechanic arts who shall attend any convention of this association may be admitted to similar privileges.

SECTIONS.

(1) The association shall be divided into two sections: (a) A section on college work and administration; (b) a section on experiment station work.

The section on college work and administration shall be composed of the presidents or acting presidents of colleges and universities represented in the association, or other representatives of such institutions duly and specifically accredited to this section, and no action on public and administrative questions shall be final without the assent of this section.

The section on experiment-station work shall be composed of the directors or acting directors of experiment stations represented in the association or of other representatives of such stations duly and specifically accredited to this section.

(2) Members of these two sections (and no others) shall be entitled to vote both in general sessions and in the section to which they respectively belong.

The representative appointed by the U. S. Bureau of Education shall be assigned to the section on college work and administration; the representative of the Office of Experiment Stations to the section on experiment-station work, and the representative of the U. S. Department of Agriculture to either section as he may elect and the section by vote authorize; but such election once made and authorized may not be changed during the sessions of a given convention.

Each section may create such divisions as it may from time to time find desirable, and shall elect its own chairman and secretary for sectional meetings, whose names shall be reported to the association for record.

(3) Each section shall conduct its own proceedings, and shall keep a record of the same, and no action of a section, by resolution or otherwise, shall be valid until the same shall have been ratified by the association in general session, and in the case provided for in the foregoing paragraph (1) shall also have been approved by the section on college work and administration.

MEETINGS.

(1) This association shall hold at least one meeting in every calendar year, to be designated as the annual convention of the association. Special meetings may be held at other times, upon the call of the executive committee, for purposes to be specified in the call.

(2) The annual convention of the association shall comprise general sessions and meetings of the sections, and provision shall be made therefor in the programme. Unless otherwise determined by vote, the association will meet in general session in the forenoons and evenings of the convention and the sections in the afternoons.

OFFICERS.

(1) The general officers of this association, to be chosen annually, shall be a president, five vice-presidents, a bibliographer, and a secretary, who shall also be treasurer, and an executive committee of five members, three of whom shall be chosen by the section on college work and administration and two by the section on experiment station work: *Provided, however*, That a member chosen by either section need not be a member of that section. The executive committee shall choose its own chairman.

(2) Each section shall, by ballot, nominate to the association in general session for its action, a chairman and a secretary for such section.

(3) The president, vice-presidents, secretary, and bibliographer of this association shall be elected by ballot upon nomination made upon the floor of the convention, and shall hold office from the close of the convention at which they are elected until their successors shall be chosen.

(4) Any person being an accredited delegate to an annual meeting of the association, or an officer of an institution which is a member of the association in full standing at the time of election, shall be eligible to office.

DUTIES OF OFFICERS.

(1) The officers of the association shall perform the duties which usually devolve upon their respective offices.

(2) The president shall deliver an address at the annual convention before the association in general session.

(3) The executive committee shall determine the time and place of the annual conventions and other meetings of the association, and shall, between such conventions and meetings, act for the association in all matters of business. It shall issue its call for the annual conventions of the association not less than sixty days before the date on which they are to be held, and for special meetings not less than ten days before such date. It shall be charged with the general arrangements and conduct of all meetings called by it. It shall designate the time and place of the convention; it shall present a well-prepared order of business—of subjects for discussion—and shall provide and arrange for the meetings of the several sections. The subjects provided for consideration by each section at any convention of the association shall concentrate the deliberations of the sections upon not more than two lines of discussion, which lines as far as possible shall be related. Not more than one-third of the working time of any annual convention of the association shall be confined to miscellaneous business.

FINANCES.

At every annual convention the association, in general session, shall provide for obtaining the funds necessary for its legitimate expenses, and may, by appropriate action, call for contributions upon the several institutions eligible to membership; and no institution shall be entitled to representation or participation in the benefits of the association unless such institution shall have made the designated contribution for the year previous to that in and for which such question of privilege shall arise, or shall have said payment remitted by the unanimous vote of the executive committee.

AMENDMENTS.

This constitution may be amended at any regular convention of the association by a two-thirds vote of the delegates present, if the number constitute a quorum: *Provided*, That notice of any proposed amendment, together with the full text thereof and the name of the mover, shall have been given at the next preceding annual convention and repeated in the call for the convention. Every such proposition of amendment shall be subject to modification or amendment in the same manner as other propositions, and the final vote on the adoption or rejection shall be taken by yeas and nays of the institutions then and there represented.

RULES OF ORDER.

(1) The executive committee shall be charged with the order of business, subject to special action of the convention, and this committee may report at any time.

(2) All business or topics proposed for discussion and all resolutions submitted for consideration of the convention shall be read and then referred, without debate, to the executive committee, to be assigned positions on the programme.

(3) Speakers invited to open discussion shall be entitled to twenty minutes each.

(4) In general discussions the ten-minute rule shall be enforced.

(5) No speaker shall be recognized a second time on any one subject while any delegate who has not spoken thereon desires to do so.

(6) The hours of meeting and adjournment adopted with the general programme shall be closely observed, unless changed by a two-thirds vote of the delegates present.

(7) The presiding officer shall enforce the parliamentary rules usual in such assemblies and not inconsistent with the foregoing.

(8) Vacancies which may arise in the membership of standing committees by death, resignation, or separation from the association, of members, shall be filled by the committees, respectively.

PROCEEDINGS OF THE ASSOCIATION OF AMERICAN AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS.

MINUTES OF THE GENERAL SESSION.

Morning Session, Tuesday, November 14, 1905.

The convention was called to order at 10 o'clock a. m., at the Shoreham Hotel, by the president, E. B. Voorhees, of New Jersey.

The proceedings were opened with prayer by W. H. S. Demarest, of New Jersey.

After the call of the roll of delegates to the convention, the regular order was suspended to give the Secretary of Agriculture opportunity to address the convention.

Address by Hon. James Wilson, Secretary of Agriculture.

Mr. President and Gentlemen: I merely dropped in to pay my respects to you, and make you welcome to the capital city of our country, and bid you godspeed in your deliberations. I was first a station man before I was a department man, and know something about what it is to break new paths through the woods along these lines, and get the farmers to send their boys to college, and coax legislatures to be generous with the research men, and all that; and when I came down here—with a good deal of reluctance—to do something in the Department of Agriculture, my prevailing thought was that I would try to make that institution subservient to the stations of the country, and to help build them up. I found that it was necessary to first build the Department up; that it was not as strong in educated scientists as it should be; that there was not very much encouragement given to men of that class, and that it was difficult to find men to do the work the American farmer wants done, without a stronger force of trained men. We found it necessary to prepare to train within ourselves. There were so many things to be done that the universities and colleges of the land had not yet set about doing, that we have had to do a great deal along the line of strengthening the Department; and so I was compelled to turn my attention to that one thing and push it in all possible directions, to select strong men, and interview Congress occasionally for increased appropriations. We have been doing what we can. We have come to the place where I have been able to give some thought to the experiment stations of the country. Of course it is desirable that the whole should work together as a unit, that whatever the Department can do to strengthen a station anywhere it shall do, and that whatever cooperation can be had between the Department and the stations shall be had along lines that are broad and national in their effects. And then when it comes to the point of what the station can do for its own locality, I come up against the position that the stations are not strong enough to do all the work that their own localities require.

The Federal Government is not giving the station men money enough. They should have more endowment. We can find facilities for cooperation with every station in the land, and we are doing that with nearly every station in some regards, but the stations have not money enough to equip their staffs sufficiently for them to attend to all the requirements of their own people. The stations have a great deal compared with what they had some years ago. They have educated men, they have organizations, they have buildings, they are in touch with their people; but they have not got the wherewithal to do the work that the people in the several localities want done, with a very few exceptions. To that end I am preparing my report for Congress and I am earnestly urging upon Congress to give the stations more money to enable them to do their work. If we could only get that body of honorable gentlemen to comprehend how much good is coming to the American people from this research work, the undertaking would be already accomplished. Our poultry interests in the United States amount to over $500,000,000 a year, and it is growing, and I hope to live to see the day when the hen of the United States will pay all the expenses of the American Government. And when Congress meets all they will have to inquire into especially will be the price of eggs. I know of no investment that the American people can make that will bring back as great returns to them as the thorough equipment of the experiment stations in every State and Territory in the land. If you take the money that is given to the Department of Agriculture and the money that is given by Congress to you and put it all together, it would not build one battle ship. If they will just give us enough to build one battle ship every year for a while we will show them what that hen will do. The people want this work done, as I have learned. They want their stations provided for in better shape than they are now. Some of the States are coming up admirably to the requirements of the stations and colleges, and helping them along. Some are not. But Congress can; and when Congress appropriates money it is only the people's money; that is all it is. And it is only necessary now that we should lay our heads together and look to Congress for this assistance that is so much needed and work all together for it and I think it will come. Congress usually tells us that they must economize: "It has come to the time in the history of the United States when rigid, strict, economy must be practiced." There is no economy I can think of so far-reaching as investments of money to help the American farmer to make the most of his acres and of himself.

Gentlemen, I thank you very much. I shall take occasion to drop in and listen to your discussions, because I feel at home with you. And so I wish you good morning.

REPORT OF THE EXECUTIVE COMMITTEE.

H. C. White, of Georgia, chairman, submitted the following report of the executive committee:

Your executive committee, appointed at the eighteenth annual convention of the association held at Des Moines, Iowa, November 1–3, 1904, met immediately upon adjournment of the convention and organized by the selection of President H. C. White, of Georgia, as chairman. Acting under instructions of the committee the chairman issued and posted to each member of the association, under date of January 10, 1905, an abstract memorandum of the proceedings of the convention of 1904. The proceedings in full were edited by the chairman and placed in the hands of the Office of Experiment Stations, U. S. Department of Agriculture, for publication, February 25, 1905. Six subsequent meetings of the committee were held, as follows: At Washington, D. C., December 7–9, 1904; January 17–19, 1905; February 8–10, March 24–26, April 12–13, and November 13. Six circulars of information concerning the results of these meetings were issued and posted to members of the association. The call for the nineteenth (1905) annual convention was issued June 20, 1905, and the programme for the convention, as arranged by the committee, November 1.

In recognition of the courteous invitation of the State University of Oregon, "in behalf of the State of Oregon and the entire Northwest," to hold the nineteenth convention of the association in Portland, Oreg., during the Lewis and Clark Exposition, the committee entered into correspondence with the officers of the exposition and others in Oregon and the Northwest, but, after due deliberation, was convinced that it would be inexpedient to accept the invitation. It was likewise found inexpedient to accept a very cordial invitation to hold the convention at the University of Illinois at the time of the installation of President James in October. At the time the call was issued for the present meeting the committee was under the apprehension that an extra session of Congress would be called to convene somewhat earlier, in November.

The results of the attention given by the committee to the several matters referred to it in specific resolutions of the last annual convention have been, in the main, communicated to members of the association by appropriate circulars, and somewhat in detail. Copies of these circulars are hereto attached as part of the record of the work of the committee. Brief reference to these matters may, therefore, suffice at this time.

In an interview with the President of the United States your committee renewed the request that had been presented to him on a former occasion in behalf of the association, that, in the appointment to the post of Assistant Secretary of Agriculture, then vacant, he would be pleased to consider the desirability that the incumbent should be one having knowledge of and sympathy with the work of the agricultural experiment stations. Received most cordially by the President, your committee was informed that he had borne in mind the representations previously made to him and had decided to appoint to the position Prof. W. M. Hays, of the Minnesota Experiment Station. As is well known to the association, the appointee to this important and responsible position is an able worker in agricultural science and a distinguished member of this association.

After several conferences with the Secretary of War and the officers of the General Staff connected with the Army War College, very desirable modifications of the regulations governing the detail of army officers to the land-grant colleges were secured. These modifications were communicated to members of the association in a circular of date April 7, 1905, and are set forth in General Orders, No. 101, of the War Department, issued June 29, 1905; the committee trusts they may be satisfactory to the institutions concerned. The committee wishes to record here its grateful appreciation of the frankness, the cordiality, and the earnest desire to meet the wishes of the association with which the committee was met by the distinguished Secretary of War (Hon. W. H. Taft), the Chief of Staff (General Chaffee), and the officers of the War College.

The committee made diligent effort and employed every resource at its command, including personal solicitation of the Speaker and other influential members of the House of Representatives, to aid Hon. H. C. Adams of Wisconsin, in securing consideration for his bill to increase the annual appropriations to the experiment stations in the last session of the Fifty-eighth Congress, but without avail. So far as could be ascertained but little objection existed to the proposition on its merits, but other considerations were represented as preventing favorable action at the time. Mr. Adams, who continued and proposes to continue his able and energetic advocacy of the measure, expresses his intention to reintroduce it in the Fifty-ninth Congress (of which he is a member), to convene in December. The committee recommends that the executive committee be instructed to cooperate diligently with Mr. Adams in his efforts to secure increased annual appropriations from the Federal Treasury to the agricultural experiment stations established under the act of 1887.

Similar efforts were made by the committee in behalf of the measure of Hon. Frank W. Mondell, of Montana, to establish and maintain schools of mines and mining in connection with the land-grant colleges, with similar result, and, apparently, for similar reasons.

Your committee is forced to the conviction that the efforts of this association to bring the National Legislature to consider seriously the important measures affecting the national usefulness of the institutions here represented, should, in order to be effective, be concentrated at a given time upon a single purpose. There can be no doubt that the increasing prosperity and the increasing growth of industrial occupations throughout the country generally and the undertaking or the supervision by the General Government of great works of public utility, in which all the States and Territories are interested, such as the irrigation of our arid lands and the conservation of our forests, will create a demand for increased industrial and technical education and research, which, in equity, the individual States should not be expected to meet from their own resources, but for which provision should be made to the States from the National Treasury. It is inevitable, as it is right, that additional appropriations of Federal funds should be made to the land-grant colleges. In due season these claims should be made, and doubtless will be, and it will be the legitimate province of this association to initiate the appropriate measures for legislation. Such measures, when carefully prepared and judiciously presented, should be advocated with all the power and the influence of this association; but, in the opinion of the committee, experience suggests the wisdom of concentration of effort upon some single comprehensive, but definite, proposition, rather than an attempted support, necessarily weaker, at the same time, of several more specialized propositions, however meritorious these in themselves may be. This attitude of the association would not prohibit, of course, such indorsement as it might be moved to give to other specific measures affecting technical education and research initiated by wise statesmen or others. The mining-school bill has been before Congress for several sessions. It is an extremely meritorious measure and has a number of earnest advocates. If the association should so direct, no doubt arrangements may be made for the introduction of this or a similar bill in the next Congress. Your committee submits to the association, however, in view of the efforts which will be required in connection with the proposition which will be made to increase the appropriations to the experiment stations, whether it would not be wise to withhold for the present specific instructions to your executive committee in connection with the mining-school bill or similar measure, leaving the committee free to concentrate its efforts to secure the passage of the Adams bill, giving, of course, to the mining-school bill, if introduced, such support as may be practicable or conditions may justify. This done, the association might, and in the judgment of the committee should, make appeal to Congress for increased appropriations to the colleges for technical education in general, with greater hope of success.

Apropos of these suggestions the committee presents a communication received by it asking action by this convention in connection with a resolution adopted by the American Forest Congress held at Washington, D. C., January 2–6, 1905, urging appropriations by Congress "for promoting the teaching of forestry and experiments in forestry in the agricultural colleges and experiment stations of the United States."

The most delicate, and, in some respects, the most important task assigned your committee by the association at the last annual convention was embodied in the following resolution: "In order that Congress may be properly informed as to the work of the agricultural experiment stations and its great value to agricultural practice and to promote satisfactory relations between the Department of Agriculture and the experiment stations, the executive committee of this association is hereby instructed to request a hearing before the proper committees of Congress for the purpose of presenting the work and claims of the agricultural experiment stations, and to continue conferences with the honorable Secretary of Agriculture relative to cooperation between his Department and the stations." In obedience to these instructions your committee sought a hearing before the House Committee on Agriculture, which was granted at a special session, January 18, 1905, most kindly and courteously arranged for by the distinguished chairman of the committee, Hon. James W. Wadsworth, of New York. The published report of the hearing has been distributed to members of the association. It was distinctly understood that no argument was to be made for any pending measures. The Adams bill had already been favorably reported by the committee. Your committee was advised to restrict its showing to the "work of the agricultural experiment stations and its great value to agricultural practice." Director Jordan, of the committee, presented in writing an able and elaborate review of the work of the stations. At the suggestion of your committee the honorable Secretary of Agriculture, the Assistant Secretary, and other officials of the Department of Agriculture were present at the hearing.

As the members of the association clearly understand, it has been feared that there might be on the part of Congress a growing tendency to underestimate the stations as a factor in agricultural progress and to regard them as occupying a subordinate position in the field of agricultural research; consequently, after mature deliberation, it was decided that the proper course in carrying out your instructions was to deal with the broad questions of public benefit and public policy and seek to establish in the congressional mind a certain point of view as to the relative importance of the stations and as to the wise distribution of national aid to agricultural research.

The situation, as it impressed itself upon us, appeared to demand, therefore, the presentation of facts along two lines: (1) A somewhat comprehensive review in brief terms of what the stations had already accomplished for practical agriculture as a justification for enlarged support, and (2) a discussion of the policy that should be followed in the development of agricultural research in the United States, whether the prevailing one of centralization with an increase of funds for the National Department greatly out of proportion to the increase of the resources of the individual stations, thereby inevitably bringing the field of research, both general and local, more and more within the scope and direction of the National Department, with the consequent minimizing of station influence, or whether the maintenance of the resources of the stations in the several States more on a parity with the resources of the National Department, thus enabling these State institutions to sustain themselves as the leading instruments of research within their respective fields.

Your committee made the broad claim, which we believe to be abundantly justified by facts, that the stations have been and still are the most important existing factor in agricultural research, and strong ground was taken in favor of the proposition that these institutions are the logical, economical, and most efficient agency for the study of the agricultural problems which are important in their respective States. The published report of the hearing is, in the main, correct, although the spirit and language of the informal questions and answers are in some instances inaccurately reported. In reading that report it has undoubtedly been made clear to you that there was on the part of the House committee an expectation that the statements of the committee would be of a somewhat different character from those which were presented, and the determination of your committee to hold itself well within its original purpose rendered the situation somewhat delicate and difficult. Your committee firmly believes that the object sought by the association in directing the request for this hearing was fully accomplished, and the results were, broadly considered, good and satisfactory. It is recommended that the association take appropriate action to secure, if practicable, the presentation of the claims of the stations to the proper consideration and support of Congress at succeeding sessions of that body.

Subsequently satisfactory conferences were held with the Secretary, the Assistant Secretary, and other officials of the Department of Agriculture on the general subject of cooperation of the Department with the stations in research work. For satisfactory reasons your committee was led to decide that it would be improper to wish to continue these conferences to a definite conclusion at the time, but it is confidently believed that a mutual and cordial understanding of the views and desires of the stations and of the Department of Agriculture in cooperative work has been reached.

In the matter of the standing committees of the association referred to your committee, it is recommended that this convention order—

(1) That the standing committees of the association be as follows:
- (a) On bibliography.
- (b) On methods of teaching in the land-grant colleges.
- (c) On graduate study.
- (d) On extension work.
- (e) On experiment station organization and policy.

(2) That each committee shall consist of five members.

(3) That the committees shall be appointed and announced by the president of the association at the concluding session of each annual convention.

(4) That the members of the committees, when practicable and unless the president, for good cause, shall otherwise determine, shall be selected from those in attendance upon the convention at which the committees are appointed.

(5) That vacancies arising between conventions shall be filled by the committee in which the vacancy has occurred.

Your committee reports with profound sorrow and regret the death during the year of President Henry H. Goodell, of the Massachusetts Agricultural College, one of the founders and, until his death, a member of this association. The peculiar relations of President Goodell to the association have led your committee to assign an hour in the programme for this convention to a memorial of his life and services, and it has been fortunate in securing the consent of President W. E. Stone, of Indiana, a pupil and friend of President Goodell, to make the leading remarks. The association will doubtless be moved to take further action to signify respect for the memory of our late distinguishd member.

The finances of the association have been economically administered and are in satisfactory condition. All obligations have been promptly met, and the report of the treasurer will show a considerable balance in the treasury.

Respectfully submitted for the committee.

H. C. White, *Chairman.*

The report was accepted. (For discussion of its recommendations see p. 42.)

REPORT OF TREASURER.

The secretary-treasurer, J. L. Hills, of Vermont, submitted the following financial statement:

Report of treasurer of the association, November 1, 1904, to November 14, 1905.

RECEIPTS.

Received of E. B. Voorhees, secretary-treasurer	$633.92	
Received, refund of advance to joint agent Des Moines convention	17.00	
Received, dues	1,545.00	
Total		$2,195.92

EXPENDITURES.

Executive committee	$1,095.45	
Secretary-treasurer, printing, postage, telegrams, etc	24.40	
Railroad certificates, Des Moines	33.20	
Stenographer, Des Moines	28.25	
Wreath, funeral President Goodell	10.00	
Expense account, President Voorhees, N. E. A. meeting	8.75	
		1,200.05
Balance in bank November 14, 1905		995.87

JOSEPH L. HILLS, *Secretary-Treasurer.*

The report was referred to an auditing committee consisting of W. D. Gibbs, of New Hampshire, and B. C. Buffum, of Wyoming, which subsequently reported as follows:

Your auditing committee beg to report that they have examined the books of the treasurer and that all accounts have been found correct.

The report was approved.

REPORT OF THE BIBLIOGRAPHER.

The bibliographer, A. C. True, of the Office of Experiment Stations, submitted the following report:

As has been the custom for a number of years, the more important bibliographies on agricultural subjects met with during the year have been noted from time to time in the Experiment Station Record, and have been compiled from that source to form the basis of this report.

An examination of the list here submitted will show the usual annual reports on the literature and general progress in animal diseases, bacteriology, chemistry, entomology, plant diseases, sericulture, zoology, and other general lines; a few special bibliographies on such subjects as the occurrence of aluminum in various products, North American Ustilagineæ, and the loco weed; and a considerable number of bibliographies or lists of references accompanying special articles or incorporated in text-books. Some of the subjects of the last class are as follows: Chemistry of proteids, nitrogen metabolism in plants, weather influences, plant breeding, formation of milk fat, soil bacteria, citrus fruits and their culture, textile fibers, timbers of commerce and their identification, and cheese ripening.

All the general bibliographies of agriculture noted in previous reports have been continued and a new one on the agricultural literature of Belgium has appeared.

Among the bibliographies appearing in bulletins and reports of the Department of Agriculture and the experiment stations are those on the following subjects: Soil bacteria and nitrogen assimilation, seed selection according to specific gravity, a study of reciprocal crosses, invisible micro-organisms, vitality and germination of seeds, the powdery mildews, Japanese persimmons, irrigation in northern Italy, care of milk, nomenclature of the apple, the relation of bacteria to the flavor of Cheddar cheese, tuberculosis of animals, comparative virulence of human and bovine tubercle bacilli for animals, potato diseases, reclamation of Cape Cod sand dunes, and relation of food to the production of milk and butter fat by dairy cows.

The bibliographies referred to are more fully described in the following list, numbering 96 in all:

Baker, C. F. A revision of American siphonaptera, or fleas, together with a complete list and bibliography of the group. Proceedings of the United States National Museum, 27 (1904), pp. 365–469.

Barbacci, O. Summarischer Bericht über die wichtigsten italienischen Arbeiten auf dem Gebiete der allgemeinen Pathologie und pathologischen Anatomie, erschienen im Jahre 1903 (A brief report on the most important Italian literature in the field of general pathology and pathological anatomy for the year 1903). Centralblatt für Allgemeine Pathologie u. Pathologische Anatomie, 15 (1904), No. 16–17, pp. 671–713. This report contains a brief review of a large number of Italian books, pamphlets, and periodical articles on general pathology classified in 17 sections according to the parts of the body affected by different diseases.

Bass, E. Therapeutische Leistungen in der Tierheilkunde während der Jahre 1901 und 1902 (A brief report of veterinary literature concerning wounds for the year 1901–2). Deutsche Tierärztliche Wochenschrift, 12 (1904), No. 37, pp. 368–371. A critical discussion of the literature of the subject in connection with a bibliography of 51 titles.

Baumgarten, P. von, and Tangl, F. Jahresbericht über die Fortschritte in der Lehre von den pathogenen Mikroorganismen, 1902 (Annual report on progress in the study of pathogenic micro-organisms, 1902). Leipzig: S. Hirzel, 1904, 1. Abt., pp. 368. This report contains extended bibliographies relating to pathogenic bacteria, fungi, and protozoa, together with brief abstracts of the more important articles.

Berlese, A. Illustrazione iconografica degli acari mirmecofili (Myrmecophilous acarids). Redia, 1 (1903), No. 2, pp. 299–474. A brief bibliography of the subject is appended to the article.

Bisson, E. Elenco di pubblicazioni attinenti alla Bachicoltura, che vennero fuori nel corso del 1903–1904 (List of publications relating to sericulture issued during the years 1903–1904). Annuario della R. Stazione Bacologica di Padova, 32 (1904), pp. 131–150. A list is given of books and periodical articles on the various lines related to sericulture as published in different languages during 1903 and 1904.

Blakeslee, A. F. Sexual reproduction in the Mucorineæ. Proceedings of the American Academy of Arts and Sciences, 40 (1904), No. 4, pp. 205–319. A bibliography of the subject concludes the paper.

Bodländer, G., et al. Jahresbericht über die Fortschritte der Chemie und verwandter Teile anderer Wissenschaften, 1904 (Annual report of the progress in chemistry and related parts of other sciences for 1904). Brunswick: Friedrich Vieweg & Son, 1905, pp. 240.

Bolton, H. C. A select bibliography of chemistry, 1492–1902, second supplement. Smithsonian Miscellaneous Collections, 44 (1904), No. 1440, pp. 462. This volume contains titles of books published between 1898 and 1902, inclusive, under the following heads: Bibliography; dictionaries; history; biography; chemistry, pure and applied; alchemical literature in the 19th century; periodicals; and academic dissertations.

Bouchez, P. Classement méthodique des travaux, mémoires, articles, publiés sur la tuberculose (A systematic list of articles relating to tuberculosis). Revue de la Tuberculose, 2. ser., 1 (1904), No. 4, pp. 310–328. An elaborate list of books, memoirs, and periodical articles published during 1904 on the various phases of tuberculosis of animals and man.

Brown, S. B. A bibliography of works upon the geology and natural resources of West Virginia, from 1704 to 1901, and a cartography of West Virginia from 1737 to 1901. West Virginia Geological Survey Bulletin 1, pp. 85.

Buchanan, R. E. A contribution to our knowledge of the development of *Prunus americana*. Proceedings of the Iowa Academy of Sciences, 1903, pp. 77–93. A list of 28 titles is appended.

Chester, F. D. Soil bacteria and nitrogen assimilation. Delaware Station Bulletin 66, pp. 24. A list of 20 references is appended.

Clark, V. A. Seed selection according to specific gravity. New York State Station Bulletin 256, pp. 367–425. A list of the more important works relating to the subject is appended.

Clinton, G. P. North American Ustilagineæ. Proceedings of the Boston Society of Natural History, 31, No. 9, pp. 329–529. A bibliography of over 200 of the more important articles relating to the Ustilagineæ is appended.

Cohnheim, O. Chemie der Eiweisskörper (The chemistry of proteids). Brunswick: Friedrich Vieweg & Son, 1904, 2. ed., pp. XII+315. The numerous footnote references given constitute an extended bibliography of the subject.

Connstein, W. Über fermentative Fettspaltung (Fermentive cleavage of fat). Ergebnisse der Physiologie, 3 (1904), pp. 194–232. A bibliography of 151 articles is given at the beginning of the article.

Cummings, M. B. Fertilization problems: A study of reciprocal crosses. Maine Station Bulletin 104, pp. 81–100. A bibliography of 32 papers on plant breeding is given.

Czapek, F. Der Stickstoff im Stoffwechsel der Pflanze (Nitrogen metabolism in plants). Ergebnisse der Physiologie, 3 (1904), pp. 309–331. A bibliography of 81 titles is given.

Darbishire, A. D. On the bearing of Mendelian principles of heredity on current theories of the origin of species. Memoirs and Proceedings of the Manchester Literary and Philosophical Society, 48 (1904), pt. 3, No. 24, pp. 19. A bibliography of the subject is appended to the article.

Deegener, P. Die Entwicklung des Darmcanals der Insecten während der Metamorphose (The development of the intestines in insects during metamorphosis). Zoologische Jahrbücher, Abtheilung für Anatomie und Ontogenie der Thiere, 20 (1904), No. 4, pp. 499–676. A brief list of references to the literature of the subject is appended.

Dexter, E. G. Weather Influences. New York and London: The Macmillan Company, 1904, pp. XXXI+286. A list of 68 references to the literature of this subject is given on pages 279–281.

Dietrich, F., et al. Bibliographie der deutschen Zeitschriften-literatur (Bibliography of German periodical literature). Leipzig: Felix Dietrich, 1905, Vols. XIV, pp. 377; XV, pp. 350. This is a subject and author index of original articles, mainly of a scientific character, published in 1904 in about 4,000 German periodicals, pamphlets, and newspapers.

Dorset, M. Invisible micro-organisms. U. S. Department of Agriculture, Bureau of Animal Industry Report 1903, pp. 139–156; Circular 57, pp. 139–156. A list of 26 references to the literature of the subject is appended to the article.

Dunstan, W. R. Report on cotton cultivation in the British Empire and in Egypt. London: Darling & Son, Ltd., 1904, pp. 40. A list of references to the literature of cotton and its cultivation is appended.

Duvel, J. W. T. The vitality and germination of seeds. U. S. Department of Agriculture, Bureau of Plant Industry Bulletin 58, pp. 96. A list of 52 references to the literature of the subject is given.

Dyé, L. Les parasites des Culicides (The parasites of Culicidæ). Archives de Parasitologie, 9 (1904), No. 1, pp. 5–77. A brief bibliography is appended.

Felt, E. P. Mosquitoes or Culicidæ of New York State. New York State Museum Bulletin 79, pp. 241–400. A bibliography containing the more important references to American species of mosquitoes is appended to the bulletin.

———, and Joutel, L. H. Monograph of the genus Saperda. New York State Museum Bulletin 74, pp. 86. References are given to the literature of the species of this genus.

Fort, H. Der Obstbau im Tätigkeitsgebiete der böhm. Sektion des Landeskulturrates für das Königreich Böhmen (Fruit culture in Bohemia). Prague: Anton Purkrábek, 1904, pp. 39. A bibliography of 58 papers on Bohemian fruit culture is given.

Fruwirth, C. Die Züchtung der landwirtschaftlichen Kulturpflanzen (The breeding of agricultural plants). Berlin: Paul Parey, 1905, vol. 1, 2. rev. ed., pp. XVIII+345. A bibliography of 59 works and articles and 31 periodicals cited in the book is given.

———. Referate über neuere Arbeiten auf dem Gebiete der Pflanzenzüchtung (References to recent work on plant breeding). Journal für Landwirtschaft, 52 (1904), No. 3, pp. 269–290. References are given to 31 recent articles on plant breeding in connection with different crops.

GLINKA, K. Latérites et "terræ rossæ" des régions tropiques et sous-tropiques et terres analogiques sous les latitudes tempérées (Laterites and red soils of tropical and subtropical latitudes and allied soils of temperate latitudes). Pochvovyedenie [Pédologie], 5 (1903), No. 3, pp. 235–261. A list of 50 titles is given.

GOGITIDSE, S. Vom Übergang des Nahrungsfettes in die Milch (The transformation of food fat into milk fat). Zeitschrift für Biologie, 46 (1905), No. 3, pp. 403–420. A bibliography is appended.

GOLDBERG, A. Ueber die Fortschritte auf dem Gebiete der Chemie des Wassers, sowie der natürlichen und künstlichen Mineralwässer (A review of progress in the chemistry of waters, especially natural and artificial mineral waters). Chemiker Zeitung, 28 (1904), No. 77, pp. 908–912. A review of investigations on this subject containing 184 references to articles which appeared during 1902 and 1903.

GOSSMANN. Die chronische Periarthritis Tarsi des Pferdes (Chronic periarthritis tarsi of horses). Monatshefte für praktische Thierheilkunde, 15 (1904), No. 9–10, pp. 385–417. A critical review of the literature of the subject in connection with a brief bibliography.

GRIPS, W., GLAGE, F., and NIEBERLE, C. Die Schweineseuche (Swine plague). Fortschritte der Veterinär-Hygiene, 2 (1904), Nos. 1, pp. 5–18; 2, pp. 49–73; 3, pp. 82–107; 4, pp. 113–135. A brief list of references to the literature of the subject is appended.

HALSTED, B. D., and KELSEY, J. A. The powdery mildews. New Jersey Stations Report 1903, pp. 517–536. A list of 34 references to the literature of the subject is appended to the article.

HENNEGUY, L. F. Les insectes (Insects). Paris: Masson & Co., 1904, pp. 804. The literature of various subjects in entomology is briefly reviewed and a bibliography of 62 pages is included in the volume.

HILGER, A., DIETRICH, T., ET AL. Jahresbericht über die Fortschritte auf dem Gesamtgebiete der Agrikultur-Chemie, 1903 (Annual report of the progress in agricultural chemistry, 1903). Berlin: Paul Parey, 1904, pp. XXXVI+661.

HINE, J. S. Tabanidæ of the western United States and Canada. Ohio State University Bulletin, 8. ser., No. 35; reprinted from Ohio Naturalist, 5 (1904), pp. 217–249. Bibliographical references are given to the species treated.

HOHL, J. Sur quelques bactéries du sol et leur importance pour l'agriculture (On some soil bacteria, and their importance in agriculture). Annuaire agricole de la Suisse, 5 (1904), No. 6, pp. 201–228. Numerous references to the literature of the subject are given in footnotes.

HUME, H. H. Citrus fruits and their culture. Jacksonville, Fla.: The H. and W. B. Drew Co., 1904, pp. XXII + 597. A list of 44 references to the literature of the subject is given on pages 557–562.

———, and REIMER, F. C. Japanese persimmons. Florida Station Bulletin 71, pp. 68–110. A list is given of 46 references to American literature relating to the Japanese persimmon.

JACCARD, P. Les Mycorhyzes et leur rôle dans la nutrition des essences forestières (Mycorrhiza and its rôle in the nutrition of forest trees). Journal Forestier Suisse, 1904, No. 2–3, pp. 30. A bibliography is given of the principal works relating to this subject.

JANASZ, S. Beschreibung einiger Zuckerrübenrassen (Description of several types of sugar beets). Mitteilungen der Landwirtschaftlichen Institute der Königlichen Universität Breslau, 2 (1904), No. 5, pp. 913–970. A list of 42 references to the literature of the subject is appended to the article.

KELLERMAN, W. A. Journal of Mycology, index. Journal of Micology, 10 (1904), No. 74, pp. 289–392. An index to the first 10 volumes of this journal.

KLEBAHN, H. Die wirtwechselnden Rostpilze (Heterœcious rust fungi). Berlin: Borntraeger Bros., 1904, pp. XXXVII + 447. This includes extended bibliographies.

KRARUP, A. V. Nogle Undersøgelser over Nedarvning og Variabilitet hos Havre, med særligt Hensyn til Muligheden af at isolere fedtrige Typer, der egner sig til Havregrynsfabrikation (Some investigations of transmission and variability in oats, with special reference to the possibility of isolating types high in fat adapted to the manufacture of shelled oats). Copenhagen: Aug. Bang, 1903, pp. 70. A bibliography of 17 references is appended.

Krüger, F. Untersuchungen über den Gürtelschorf der Zuckerrüben (Investigations on the zonal scab of beets). Arbeiten aus der Biologischen Abteilung für Land- und Forstwirtschaft am Kaiserlichen Gesundheitsamte, 4 (1904), No. 3, pp. 254–318. A bibliography of 92 titles is appended to the article.

Langstein, L. Die Kohlehydratbildung aus Eiweiss (Formation of carbohydrates from protein). Ergebnisse der Physiologie, 3 (1904), pp. 453–496. A bibliography of 84 articles is given.

Langworthy, C. F., and Austen, P. T. The occurrence of aluminium in vegetable products, animal products, and natural waters. New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1904, pp. V + 168. A bibliography of 671 references to reports on the occurrence of aluminium in the various products named.

Leidy, J. Researches in helminthology and parasitology. Smithsonian Miscellaneous Collections, 46, No. 1477, pp. 1–281. Bibliography and abstracts of the publications of Joseph Leidy are given.

Lucas, R. Bericht über die wissenschaftlichen Leistungen im Gebiete der Entomologie während des Jahres 1900 (Report on scientific work in the field of entomology during 1900). Archiv für Naturgeschichte, 67 (1904), II, No. 2, 2. half, pp. 289–944. An extensive bibliography of literature relating to Hymenoptera and Lepidoptera published during the year 1900.

Luginger, J. Streptothricheen als Ursache von Endocarditis beim Rind (Streptothrices as the cause of endocarditis in cattle). Monatshefte für Praktische Thierheilkunde, 15 (1904), No. 7–8, pp. 289–336. The literature relating to the bacteriology of endocarditis in animals and man is critically reviewed in connection with a brief bibliography.

McAlpine, D. Native or Blackfellows's bread. The Journal of the Department of Agriculture of Victoria, 2 (1904), No. 10, pp. 1012–1020. A list of 20 references to the literature of the subject is appended.

Matthews, J. M. The textile fibers: Their physical, microscopical, and chemical properties. New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1904, pp. VII + 288. A bibliography of 75 references to the literature of the subject is given in an appendix.

Mayer, P. Zoologischer Jahresbericht für 1903 (Zoological Yearbook for 1903). Berlin: R. Friedländer & Son, 1904, pp. VIII+596. Detailed bibliographic lists relating to the various groups of animals. The more important publications under each group are briefly abstracted.

Mead, E. Irrigation in Northern Italy, I. U. S. Department of Agriculture, Office of Experiment Stations Bulletin 144, pp. 100. A bibliography containing references to 100 of the more important works relating to Italian irrigation is given on pages 17–23

Meyer, R., et al. Jahrbuch der Chemie (Yearbook of chemistry). Brunswick: Friedrich Viewig & Son, 1904, vol. 13, pp. VII+600. A biographical and bibliographical review of the more important advances in pure and applied chemistry during the year 1903.

Michniewicz, A. R. Die Lösungsweise der Reservestoffe in den Zellwänden der Samen bei ihrer Keimung (The solution of reserve material in the cell walls of seed during germination). Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften [Vienna], Mathematisch-Naturwissenschaftliche Klasse, 112 (1903), No. 4–7, pp. 483–510. A brief bibliography is appended.

Morse, M. Batrachians and reptiles of Ohio. Ohio State University Bulletin, 8. ser., No. 18, pp. 91–144. Bibliographic references are given to the species known to occur within the State.

Nedokvochavev, N. Über die Speicherung und Reduction der Nitrate in den Pflanzen (Conditions of accumulation and reduction of nitrates in plants). Izvyestiya Moskovskagho Sel'skokhozyaĭstvennagho Instītuta [Annales de l'Institut Agronomique de Moscou], 10 (1904), No. 1, pp. 257–347. A bibliography including 127 titles is appended.

Neuberg, C. Die Physiologie der Pentosen und der Glukuronsäure (The physiology of pentoses and gluconic acid). Ergebnisse der Physiologie, 3 (1904), pp. 373–452. A bibliography of 292 titles is given.

Nicholls, A. G. An experimental study on the effect of the blood sera of normal and immunized goats in modifying the progress of tuberculous infection. Proceedings and Transactions of the Royal Society of Canada, 2. ser., 9 (1903), IV, pp. 3–32. A list of 120 references to the literature of serum treatment of tuberculosis is appended to the article.

Opitz, K. Untersuchungen über Bewurzelung und Bestockung einiger Getreidesorten (Investigations on the rooting and tillering of grains). Mitteilungen der Landwirtschaftlichen Institute der Königlichen Universität Breslau, 2 (1904), No. 4, pp. 749–816. Numerous footnote references are given and a bibliography of 78 titles is appended to the article.

Ottavi, E., Marescalchi, A., et al. Bibliographia agronomica universalis. Casale: Ottavi Bros., 1904, No. 6, pp. 89–192. This is a continuation of the general agricultural bibliography noted in previous reports. The number of articles noted has reached 3,786.

Pearson, R. A. Syllabus of illustrated lecture on the care of milk. U. S. Department of Agriculture, Office of Experiment Stations, Farmers' Institute Lecture 1, pp. 12. References to recent literature of this subject are appended.

Phillips, W. F. R., and Kimball, H. H. Recent papers bearing on meteorology. U. S. Department of Agriculture, Weather Bureau. Monthly Weather Review, 32 (1904), pp. 9, 65, 126, 174, 227, 275, 308, 369, 414, 461, 502, 552.

Popper, R. Über die Formelemente des Colostrums, ihre Entstehung und Bedeutung (On the formed elements of colostrum, their origin and significance). Archiv für die Gesammte Physiologie des Menschen und der Thiere, 105 (1904), No. 11–12, pp. 573–613. A bibliography is appended to the article.

Ragan, W. H. Nomenclature of the apple; a catalogue of the known varieties referred to in American publications from 1804 to 1904. U. S. Department of Agriculture, Bureau of Plant Industry Bulletin 56, pp. 383. A bibliography of the literature consulted, comprising 233 papers, is appended.

Richards, Ellen H., and Woodman, A. G. Air, water, and food from a sanitary standpoint. New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1904, 2. ed., rev. and enl., pp. 262. A list is given of some of the more important works bearing on the subjects treated.

Rogers, L. A. The relation of bacteria to the flavors of Cheddar cheese. U. S. Department of Agriculture, Bureau of Animal Industry Bulletin 62, pp. 38. The appended bibliography furnishes references to 21 articles used in this review.

Salmon, D. E. Some observations on the tuberculosis of animals. U. S. Department of Agriculture, Bureau of Animal Industry Report 1903, pp. 69–88. A list of 30 references to the literature of this subject is appended to the article.

Sayre, L. E. Bibliography of the loco weed. Transactions of the Kansas Academy of Science, 19 (1903–4), pp. 194–197. A bibliography of articles relating to the loco weed.

Schenke, V. Phosphorsaurer Kalk als Futterbeigabe (Calcium phosphate as a part of a ration). Die Landwirtschaftlichen Versuchs-Stationen, 58 (1903), No. 3–4, pp. 291–312. The article includes a list of 56 references to the literature of the subject.

Schweinitz, E. A. de, Dorset, M., and Schroeder, E. C. Experiments concerning tuberculosis. II, The comparative virulence of human and bovine tubercle bacilli for some large animals. U. S. Department of Agriculture, Bureau of Animal Industry Bulletin 52, pt. 2, pp. 100. A brief bibliography of the subject is appended.

Seligmann, E. Ueber den Einfluss einiger Aldehyde, besonders des Formalins, auf die Oxydationsfermente der Milch und des Gummi arabicums (On the influence of certain aldehydes, especially formaldehyde, on the oxidizing ferments in milk and gum arabic). Zeitschrift für Hygiene und Infectionskrankheiten, 50 (1905), No. 1, pp. 97–122. A bibliography is appended.

Smith, T., and Reagh, A. L. The agglutination affinities of related bacteria parasitic in different hosts. Studies from the Rockefeller Institute for Medical Research, 1 (1904), Art. 12; reprinted from Journal of Medical Research, 9 (1903), No. 3, pp. 270–300. A bibliography of about 20 publications relating to the subject completes the paper.

Stazzi, P. Il corpuscolo di Negri e la diagnosi rapida della rabbia (Negri's corpuscle and the rapid diagnosis of rabies). La Clinica Veterinaria [Milan], 27 (1904), Nos. 42, pp. 249–254; 44, pp. 261–265; 46, pp. 273–277. A brief list of references to the literature of the subject is appended.

Stewart, F. C., and Eustace, H. J. Syllabus of illustrated lecture on potato diseases and their treatment. U. S. Department of Agriculture, Office of Experiment Stations, Farmers' Institute Lecture 2, pp. 30. A list of 47 references is appended.

Stiles, C. W., and Hassall, A. Index-catalogue of medical and veterinary zoology. U. S. Department of Agriculture, Bureau of Animal Industry Bulletin 39, pts. 7–13, pp. 511–950. These parts of this bulletin include authors whose names begin with the letters G to K, inclusive.

Stoklasa, J., et al. Ueber die Isolierung gärungserregender Enzyme aus Kuhmilch (On the isolation of fermentative enzyms from cows' milk). Zeitschrift für das Landwirtschaftliche Versuchswesen in Oesterreich, 7 (1904), No. 11, pp. 755–774. A list of about 30 references is appended.

Stone, H. The timbers of commerce and their identification. London: William Rider & Son, Ltd., pp. XXXVIII+311. A bibliography of 132 references to the literature of the subject is given.

Teichert. Bakteriologisch-chemische Studien über die Butter in der Provinz Posen mit besonderer Berücksichtigung der Tuberkelbacillen (Bacteriological and chemical studies of the butter in the Province of Posen, with especial reference to the tubercle bacillus). Inaugural Dissertation, University of Jena, 1904. A bibliography of the subject is included.

Vandevelde, A. J. J. Répertoire des travaux publiés sur la composition, l'analyse et les falsifications des denrées alimentaires pendant l'année 1903 (Review of the literature of composition, analysis, and adulteration of foods for the year 1903). Separate from Bulletin du Service de Surveillance de la Fabrication et du Commerce des Denrées Alimentaires, 1904, pp. 101. This contains 725 references and is the fourth volume on this subject.

Voss, W. Über die durch Pfropfen herbeigeführte Symbiose einiger Vitisarten, ein Versuch zur Lösung der Frage nach dem Dasein der Pfrophhybriden (The symbiosis of grape species in grafting; an experiment for the solution of the question of the existence of graft hybrids). Landwirtschaftliche Jahrbücher, 33 (1904), No. 6, pp. 961–996. A bibliography of 56 papers on the subject is included.

Waele, H. de, Sugg, E., and Vandevelde, A. J. J. Sur l'obtention de lait cru stérile (Obtaining raw sterile milk). Centralblatt für Bakteriologie, Parasitenkunde u. Infektionskrankheiten, 2. Abt., 13 (1904), No. 1–3, pp. 30–35. A list of 21 titles is appended to the article.

Weber, S. Über die Beeinflussung des Stoffwechsels durch einige pharmakologisch wichtige Stoffe (The influence of active pharmacological principles on metabolism). Ergebnisse der Physiologie, 3 (1904), pp. 233–289. A bibliography of 550 articles is given.

Westgate, J. M. Reclamation of Cape Cod sand dunes. U. S. Department of Agriculture, Bureau of Plant Industry Bulletin 65, pp. 38. The bulletin concludes with a brief bibliography of the literature relating to the subject.

Winkler, W. Der gegenwärtige Stand der Käsereifungsfrage (The present status of the question of cheese ripening). Centralblatt für Bakteriologie, Parasitenkunde u. Infektionskrankheiten, 2. Abt., 12 (1904), No. 4–5, pp. 97–105; 9–10, pp. 273–289. A review of the literature of this subject with an appended bibliography of 51 articles.

Woll, F. W. On the relation of food to the production of milk and butter fat by dairy cows. Wisconsin Station Bulletin 116, pp. 85. A list of 151 references is given in an appendix to this bulletin.

Bibliographie agricole Belge. (Agricultural bibliography of Belgium). Brussels: J. Vandervorst, pp. 170. This is the first part of a bibliography of Belgian agricultural literature, and includes all books, pamphlets, and articles of more than 10 pages which have appeared since 1880. Lists of the publications of the Belgian Department of Agriculture and of the principal agricultural journals of Belgium are appended.

Bibliographie der Deutschen naturwissenschaftlichen Litteratur (Bibliography of German scientific literature). Berlin: Hermann Paetel, 1904, vol. 5, Nos. 25–38, pp. 785–1240.

International Catalogue of Scientific Literature, second annual issue. D—Chemistry, 1904, Oct., pp. VIII+1002; F—Meteorology, 1904, Sept., pp. VIII+296; L—General Biology, 1904, June, pp. VIII+120; M—Botany, 1904, December, pp. VIII+1114; Q—Physiology, 1904, July, pt. 1, pp. VIII+620; pt. 2, pp. 621–1360. These volumes consist of author and subject indexes to the literature of the subjects mentioned.

A. C. True. In this connection I desire to call attention to the fact that the Office of Experiment Stations wishes to keep up to date its collection of books written by college and station officers. As the result of the St. Louis Exposition we have now a quite complete collection, pretty well up to date, but as you are publishing books, be sure to remember the Office of Experiment Stations and its collection.

The report of the bibliographer was accepted.

UNIFORM FERTILIZER AND FEEDING STUFF LEGISLATION.

H. J. Wheeler, of Rhode Island, chairman of this committee, submitted the following report:

Your committee begs to report that during the past year requests have been received from several States where feeding-stuff legislation was either pending or anticipated for suggestions concerning such acts. In all such cases the attention of inquirers has been directed to the points of uniformity already adopted and recommended by this association.

Since the last report concerning the efforts to secure uniformity in fertilizer laws, the law of the State of New York has been modified, conforming in its chief features to the existing recommendations of this association and of the Association of Official Agricultural Chemists. The State of Tennessee is also reported to have passed a new act based upon these recommendations but with some modifications. It is reported from Florida that the law of that State, which was amended in 1901, based upon the recommendations, has been found to be a vast improvement upon the former act.

A new fertilizer law was passed by the State of Kansas in 1903 which differed in many essential details from the association's recommendations and which has been officially recognized in that State as capable of much improvement.

It will be recalled that in a former report it was shown that the recommendations have already been largely adopted in recent modification of the laws of a considerable number of the States. Nevada, Wyoming, New Mexico, Colorado, Minnesota, Arizona, Oregon, Nebraska, and Utah are reported to have no fertilizer laws. Inquiries have nevertheless been received from Utah and Colorado concerning the recommendations of this association, indicating that the matter is already coming under consideration in that State.

Respectfully submitted.

H. J. WHEELER,
CHAS. D. WOODS,
E. H. JENKINS,
M. A. SCOVELL,
H. P. ARMSBY,
Committee.

The report was accepted.

On motion of J. L. Hills, of Vermont, delegates and visitors in attendance at the convention of the Association of State Universities were admitted to the privileges of the floor.

REPORT OF COMMITTEE ON METHODS OF SEED TESTING.

The following report was read by the secretary:

The standing committee on methods of seed testing begs to report that, since the adoption by your association of the revised rules for seed testing, nothing on the subject has called for the attention of this committee, or for report to the association.

Respectfully submitted for the committee.

E. H. JENKINS, *Chairman.*

The report was accepted.

FORESTRY IN LAND-GRANT INSTITUTIONS.

S. B. Green, of Minnesota, offered the following resolution:

Whereas the forests of this country are fast disappearing, and little or no attention is being paid to their renewal; and

Whereas the development of this country is seriously threatened by a shortage in timber supply: Therefore be it

Resolved by the Association of American Agricultural Colleges and Experiment Stations in convention assembled, First. That the national-forestry policy of this country should include provision for education and experimentation in forestry by the agricultural colleges and experiment stations of the different States and Territories.

Second. That the Congress of the United States be asked to appropriate adequate sums for the promotion of forest education and experimentation in the agricultural colleges and experiment stations of the United States.

Third. That the executive committee of this association be, and is hereby, directed to prepare a suitable bill with this purpose in view, and strongly urge its passage by Congress at its forthcoming session.

The resolution was referred to the executive committee. (For further action see p. 53.)

INSTRUCTIONS TO THE EXECUTIVE COMMITTEE REGARDING CONGRESSIONAL LEGISLATION.

G. W. Atherton, of Pennsylvania, offered the following resolution:

Resolved, That the executive committee be, and hereby is, instructed to use its best efforts to promote the passage of the Adams bill, and also to give such assistance to the Mondell bill as in its judgment may be advisable and as circumstances may justify.

G. W. ATHERTON. The resolution, I hope, is plain enough to explain its own purpose and purport, which is to concentrate the influence of the association on the passage of the Adams bill. But I would like to say, as explaining and interpreting the second clause, that there is a feeling on the part of those who are interested in the Mondell bill that they will not get support enough from this association. The Association of State Mining Schools is naturally pushing the Mondell bill, and there is no reason to suppose that this asociation, from its past history and its past committal to this bill, would throw any obstacles in the way of that bill, and that it had definitely decided to push for one thing now. The purpose of the resolution is to concentrate the attention of the committee on the Adams bill and at the same time to leave it free to act, in view of the contingencies that arise in the progress of legislation.

The resolution was referred to the executive committee. (For further action see p. 42.)

E. A. BRYAN, of Washington. I think there is perhaps some misunderstanding about a reference to the executive committee. As I understand, the one purpose of such reference is to fix a suitable time for the consideration of the matter, and not in order that the executive committee may make a report on the advisability or inadvisability of this or any other resolution.

The PRESIDENT. The provision is that resolutions shall be referred to the executive committee without debate, to be assigned a place upon the programme.

E. A. BRYAN. And not for the purpose of eliciting their views.

K. L. Butterfield, of Rhode Island, offered the following resolution:

RESOLUTION REGARDING A DEPARTMENT OF AGRICULTURAL EDUCATION IN THE NATIONAL EDUCATIONAL ASSOCIATION.

Whereas this association believes that the questions involved in the general and the technical education of the rural people are of sufficient importance to warrant special recognition in the great gatherings of American educators: Therefore, be it

Resolved, That our executive committee be hereby instructed to take such steps as they may consider necessary in an endeavor to secure the consent of the National Educational Association to add to its list of special departments a department or departments on rural and agricultural education.

The resolution was referred to the executive committee. (For action on it, see p. 47.)

Thereupon, at 12 o'clock noon, the convention adjourned until 8 p. m.

EVENING SESSION, TUESDAY, NOVEMBER 14, 1905.

The convention was called to order at 8.30 o'clock p. m., J. C. Hardy, of Mississippi, first vice-president, in the chair.

STATISTICAL WORK OF THE U. S. DEPARTMENT OF AGRICULTURE.

H. J. Waters, of Missouri, offered a resolution relating to this work, which was referred to the executive committee. (For action on it see p. 49.)

PETITION OF ASSOCIATION OF MINING SCHOOLS REGARDING INDORSEMENT OF MONDELL BILL.

A petition from the National Association of State Mining Schools, requesting a reindorsement by the association of the Mondell bill, was presented by H. C. White, of Georgia, and was referred to the executive committee. (See p. 42.)

President E. B. Voorhees, of New Jersey, was introduced and delivered the annual presidential address, as follows:

ANNUAL ADDRESS OF THE PRESIDENT OF THE ASSOCIATION.

A review of the proceedings of our annual conventions and their relations to the development of the work of the colleges and stations in the last eighteen years would doubtless be profitable and interesting at this time, as showing the influence of this association in unifying sentiment and directing and concentrating effort along the lines of progress. I shall, however, refer but briefly to our early history, but will discuss in a general way some of our present-day problems, particularly in their relation to the education of the farmer and his family. In the early history of this association there were, as was to be expected, two distinct views held by the officers of the institutions, as to the character of the larger work that should be done by the colleges provided for by the Hatch Act of 1887, and the Morrill Act of 1890.

On the one hand, those who had received their training in our older institutions, were conservative and adhered strongly to the old landmarks in reference to educational methods, and with glowing periods and persuasive logic demanded in the founding and developing of these new institutions that the old curriculum of studies, which had for centuries been found to fulfill the requirements in the development of the intellectual faculties of man, should be, in large part, retained. They urged that "the student must be taught to think; that the powers of reason and memory could be strengthened in no way quite so well as by a rather close adherence to the classical studies." On the other hand, those who had been trained mainly in the field of action urged quite as strenuously that "the time for a new departure had come; that students should be taught to do, as well as to think, and that the powers of reason, memory, and observation could be developed quite as well by a study of science and its manifestations and applications as by the study of subjects formerly regarded as alone capable of leading to that end, and demanded the entire elimination of these from the agricultural and other courses of a rather scientific character."

It is evident that rapid progress along the right lines could not be made as long as these opposing and, in a sense, antagonistic views were held. A study of the proceedings of the conventions shows, however, that wise concessions were made from time to time on both sides. The conservative parties were unable—nor did they persist in their attempt—to resist the logic of the situation. The demand for workers in technical fields was imperative, and would permit only in exceptional cases that thorough education which the old curriculum afforded. The others learned, on their part, that technical studies alone, while training men more quickly for practical activity, could not in themselves be regarded as sufficient from the broader educational standpoint. The best men in the technical pursuits, the leaders, whether in chemistry, engineering, electricity, the scientists in the various branches of experiment station work, had received, as a rule, a broader training than was made possible by the strictly technical studies, and thus a judicious adjustment was effected. The excellent standing of these State institutions to-day; their, in a sense, conservative, though progressive, character; their adaptation to the newer conditions and requirements are a monument to these men, who, by their clearness of vision, breadth of view, and unselfishness of purpose, have interpreted the trend of the times and its educational needs. The representatives of these institutions, who were wise enough to retain the best of the old, while including at the same time the best of the new, have secured for them that permanency and that degree of present usefulness which command the respect and admiration of those interested in industrial education in this and all countries. A result like this could not have been accomplished without the influence of this representative organization.

On our experiment station side, too, there have been men who have insisted that any permanent good to be accomplished must come from investigations of a high order; that men should absent themselves from the world and, in their laboratories, seek to know the mysteries of nature, and from their discoveries to formulate principles which, in their application, would be of inestimable service to the world. Others have urged quite as strongly that the experiment station should first demonstrate to the farmers the utility of the stations' work; prove, by tests in the field, the barn, and the laboratory, that the principles already known are of the greatest service when applied in practice. The farmers were crying for bread, in the shape of practical information; why give them a stone, in the shape of scientific disquisitions, upon agricultural matters to be sure, but beyond their comprehension? "To know how to do," rather than to "know how to enjoy the fruits of higher scientific research," is what the farmer needs. As in the case of the colleges, the stations, too, have made great progress in their development along right lines. There has been, on the whole, a fair adjustment and combination of doing and thinking, and many stations are now equipped for and are pursuing highly scientific investigations, without at the same time losing touch with the farmer, for whom, primarily, the stations were established. Great things have been accomplished, and, as an evidence of this, the following figures may be quoted:

In 1892, when the first complete statistical report of these institutions was made, there were in the various agricultural colleges 11,358 students, of whom 3,460 were taking agricultural courses. The total revenues in that year were $3,444,426, of which $1,716,108 was received from Federal grants; $1,111,588 was derived from the various States, and the balance from fees and miscellaneous sources. In 1904 there was a total of 56,226 students in the various land-grant colleges, of which 12,033 were taking courses in agriculture or allied subjects. The Federal aid granted in that year was $2,015,136, and State aid, including appropriations for buildings and special purposes, $5,617,902; in other words, $2.17 was received from the various States for every dollar appropriated by the United States Government.

In 1892 the several States received under the Hatch Act $690,000; in that year 13 States appropriated a total of $152,000. In 1904 the increase from the Federal Treasury was but $15,000, yet the number of States contributing to the support of their experiment stations had increased to 34, and the amount appropriated from $152,000 to $522,391, or a sum from State treasuries nearly equal to that from Federal grants.

While the association is, therefore, to be congratulated upon the great progress that has been made by both colleges and stations in the past twelve years, as shown by these figures, it should not be assumed for one moment that because the institutions are now well established upon foundations broad and deep; that because the superstructures in course of erection are showing such evidences of beauty of form, harmony in adjustment, and utility of purpose, the completion of the work may safely be left to itself. There has been no time in the history of these institutions that called for greater wisdom of direction than the present moment; too great an increase in material wealth may easily be a menace, rather than an aid to right development and true progress, for the statement that "a certain amount of money is necessary, both for the individual and for the Government," is applicable to educational institutions. It must be remembered that the value of these institutions, both stations and colleges, is not determined so much by fine buildings, elaborate equipment, and exceptional facilities for work as by the men who direct the work of the various departments, and it is quite conceivable that the supply of men properly trained may not keep pace with the growth of equipment and endowment. I am persuaded, also, that the increase in the number of students in a college is not always a measure of its success and usefulness, or that the number of bulletins issued from an experiment station is a measure of the value of the work done there. Many boys may have been drawn from the farms to the shorter courses in the colleges by the picturesque circulars calling attention to the great advantages to be derived from "a little learning." These, as a rule, do not appeal to the best men, but rather to those who are attracted by the "get-rich-quick" plan, who from a smattering of many things can take positions which will enable them to get a living more easily than on the farm. It is a fact, too, that many of the most valuable bulletins of the stations are not read, and if read are not appreciated at their true worth.

The growth in material things, as evidenced by large State appropriations, may, in other words, indicate not so much the awakening of the farmer himself, or his realization of his educational needs, and the demand that they be satisfied, as the progress made in the various States in the entirely legitimate and proper education of the nonfarmer members of the legislature, for it is a notorious fact, that of the States where farmers constitute a large proportion of the members of the legislature, many have been the most backward in voting appropriations for the college of agriculture or for the experiment station. The increase in the number of genuine students in the colleges—and by "genuine" I mean those who attend for the purpose of acquiring knowledge and the direct helpfulness of the experiment stations to the farmers—have been due to the influence of the work of, or of personal contact with, one or more men in the institutions, whose breadth of view, sincerity of purpose, and strength of character have inspired both young and old with the desire to sit at their feet, rather than to buildings, equipment, or exceptional facilities. I have no doubt that the members of this association have felt the possible dangers pointed out here as constituting a real menace to future progress, and I am sure I shall not be misunderstood when I urge that the pressing needs of to-day are for men rather than equipment, and that, paradoxical as it may seem, the duty of this association, as representing the institutions in the various States, is to see to it that both a broader and a more elementary education shall be provided. The character of the work of the experiment stations is not high enough, because of the lack of a sufficient number of broadly trained men in the various departments of chemistry, botany, entomology, etc., who are capable of planning highly scientific investigations. Analysts who are unable to plan a comprehensive experiment, or to interpret their experimental results, are not chemists; collectors, unable to originate or pursue a definite and helpful line of investigation, are not botanists or entomologists. Experiment stations need a larger number of true scientists, if their work is to be of a more permanent character. It may be said that scientific investigators of a higher order, like poets, "are born, not made," which is undoubtedly true, and hence the greater necessity of a larger number of broadly trained students from among whom men may be drawn that shall be capable teachers and investigators. The teaching functions of the experiment stations must be exercised as long as the great mass of farmers are unfamiliar with the applications of the principles of science, and the beneficial results of investigations must of necessity remain largely indirect; none the less the influence of the stations has already proved of inestimable value to the country. What it will be when its work touches directly all of the various interests of the people, as it surely must, can only be faintly conjectured. The opinion has been expressed that the establishment of the land-grant colleges, together with those important branches, the experiment stations, was one of the most beneficent acts of legislation ever enacted by this Government. This opinion is concurred in by all who have given the subject careful thought, not only because it has to do primarily with the education and consequent uplifting of the industrial classes, but also because in its best sense it has to do with the development, conservation, and use of the nation's wealth, viz, the elements which constitute its soil, increasing the intelligence and broadening the views both of the man who directs nature's energies in the creation of new products, and of him who transforms them into merchantable forms or transfers them to the consumers. I do not agree with those who regard the land-grant college as primarily the place where the student may secure technical education that shall best fit him for his duties as a farmer. The land-grant college is the farmer's college, but it should furnish opportunities for the farmer's boy to secure a training along the lines which shall best suit his inclinations, though I believe that those who shall study engineering, or law, or medicine, or other technical or professional pursuits, or shall fit themselves there to be more helpful to their fellow-men in any direction, should acquire there such a knowledge of the principles of agricultural science as to enable them to at least understand the relation of this, the primary industry, to the other great industries of the world, and the relation of the latter to the products of the farm, as well as to the progress of the country and the benefit of all the people. This organization, therefore, represents in an educational sense the greatest of all human interests, because it includes them all. Each State here represented is an empire in itself, when considered from the standpoint of potential development. The possibilities in this direction are so great, particularly as concerns the need of improvement in economic and social conditions, that those engaged in the work can not help but chafe under the restraint caused by the inertness of those forces, governmental and otherwise, which should be exercised in their behalf.

Our first question, then, is, What is the responsibility of this organization? for it seems to me that the responsibility for the development and progress of agriculture must rest most of all with the institutions that we represent. I am well aware that it is the essential duty of an agricultural college, in common with others, to give proper instruction to its students, yet because the agricultural college in any State is, or should be, at the fountain head of the agricultural education, it is not merely directly responsible for the education of the students who come to its halls, but indirectly responsible for the education of the masses engaged in agriculture. It is not sufficient that this work should be touched here and there by the agricultural college, for the mass of farmers shall be so instructed as to enable them to take advantage in a practical way of the knowledge in our possession. The last United States census showed that there were in the United States 5,739,657 farms and about 11,000,000 farmers, who, with their families, constitute about three-fifths of our population. The Report of the Office of Experiment Stations, in its statistics of land-grant colleges for 1904, shows that there have been graduated from these institutions, since their organization, 57,909 students, or practically one student for each hundred farms. Had all of these students been graduated from the agricultural courses, and had they all engaged in farming, only 1 per cent of the farms of the country would have been thus directly influenced by the agricultural colleges. The facts are, however, that a very small proportion of this total number of students were graduated from the agricultural courses, and of these a very large proportion were not directly engaged in farming, though interested in allied occupations, as in the manufacture of fertilizers, the management of dairies or creameries, the editing of newspapers, or in teaching. It is a fact that the number of graduates from the agricultural courses is too small, even now, to make it possible for the various institutions to secure enough competent instructors, hence the number of men who have been educated in these colleges, and who are engaged in farming, is too small to directly affect agricultural practice in the various States. The wonder is, therefore, that any genuine progress has been made, rather than that greater progress has not been made. Our progress can be accounted for by the wealth of our natural resources, a progress that has been accompanied by woeful waste.

That this would apply to any other industry which has made proportionately greater progress than has been made in farming is true in a sense, but it must be remembered that in other industrial lines there are many schools where technical education may be obtained, whereas in the case of the farmer his only school, practically, is his agricultural college, though fortunately there are a few notable exceptions. The only means of education available to him aside from his agricultural college may be found in the various subordinate agencies, such as the farmers' institutes, the grange, the press, the State boards of agriculture, the agricultural and horticultural societies, and farmers' clubs, and the direct influence of these is really quite limited. The farmers' institutes, which are directly educational in their methods, according to available statistics reach less than 5 per cent of those living upon farms, and these attend institutes because they are already in touch with the experiment stations; they do not reach, as a rule, those who are in the greatest need.

I do not desire in any way to belittle the very great service that has been rendered by these organizations, for I appreciate fully their value, but it can not be claimed even by the broadest interpretation of the term "education" that they have been truly educational factors in the sense that the college or school is, where prescribed studies are required that are pursued in a logical way. It is impossible to achieve great ends, or to make genuine and general progress in any calling, without having those who are directly interested so educated and trained in the fundamental principles upon which the industry rests as to enable them to agree as a unit upon essentials.

It may be said also that this education of which we speak is not selfish in its character, for while it concerns directly the farmer and the farmer's interests, the actual result of the broader dissemination of exact knowledge will ultimately redound to the benefit of the entire people engaged in whatever line of industry. This doubtless is true in a degree of all forms of education. Nevertheless it seems to me that this education, which is so intimately related to the issues of life, must be considered of relatively greater importance than any other, for it is, in the long run, a prerequisite either to the material enjoyment or to the usefulness of man, whatever his education may have been in other directions. This view is based upon the fact that the capital stock of any country, and, therefore, its present and prospective wealth, as well as the means whereby the wealth may be utilized for the uplifting of mankind, lies in the natural resources of that country. In an agricultural country these resources are in the soil, and since the value of the soil, or its sustained power to produce crops, is measured by the content of nitrogen, phosphoric acid, and potash, together with the conditions which make them available to plants, it follows that the future progress of that country is measured by the intelligence with which these constituent elements are used. The wasteful use of these, either in the systems of farm practice adopted or in the crude transformations that take place in their manufacture and distribution, must reduce the possible value of the resources, and, therefore, the adequate return in culture or material wealth, which alone permits of these enjoyments accompanying a higher civilization.

It is a notorious fact that the farm practice in this country up to the present time has been wasteful in all these directions, and while this wasteful practice can not be charged exclusively to ignorance on the part of the farmers themselves, the result is identical, and unless we increase our knowledge of the means by which the natural forces which are always active may be understood and controlled by the mass of farmers, the time is not far distant when this country, in common with older countries, will be confronted with the problem of feeding the people.

I am well aware that these natural forces of sun, air, water, and temperature, and the principles upon which the sciences of geology, of chemistry, of biology, and of physics are based, and which are all concerned in the proper utilization of these constituents of our soils, and consequently the true progress of the nation, have existed since the beginning of time. Real progress in their application was not apparent, however, until the investigations of the geologist, the chemist, the botanist, and the physicist had established a reasonable basis for a theory that would account for the various phenomena involved in the work, and it is through the broader dissemination of the results of the work of these investigators in other countries that the latter have been enabled to maintain and increase the fertility of their soils and to provide a larger measure for the feeding of their people. The conservation of those basic elements in the countries in question is partly facilitated, too, by the disregard of these principles in our country. There is, I admit, no immediate danger of a shortage of agricultural products in this country; neither is there any immediate danger of a general dissemination of knowledge that will result in materially changing our farm practice. It is a gradual process in either case, but unless more active measures be taken and strenuous efforts made to provide for the future, the rate of progress made by our nation in all those directions, which has made us truly great, will be materially reduced.

Aside from the primary problem of producing crops, and of conserving at the same time the principal elements involved in their growth, we must recognize that the allied problems of labor, transportation, social conditions, political and economic forces, which create so much dissatisfaction and unrest among the farmers, as among others, are the result, in part at least, of the ignorance of the fundamental principles upon which the industry rests. It is a common saying that farming as a business depends more upon the man than upon the conditions, and if we will follow up this matter we shall find that where the individual is successful, he is so because he has either by intuition or force of character succeeded in educating himself. He has acquired, by his experience and contact with men, those attributes which compel success, which the agricultural college is destined to give. Take the question of labor, which is such an important problem at the present time in our Eastern States and in the vicinity of large cities in all sections of the country. There can be no good reason, if economic conditions were properly adjusted, why the farming business should not fairly compete in obtaining labor with the manufacturer, whose business it is to prepare for consumption the products which the farmer raises; and yet if the farmer were to pay the same relative rate of wages and grant to labor the same number of hours that are maintained in the mills he would not be able to earn living wages for himself, much less secure the profit which the manufacturers demand. John Mitchell, the celebrated labor leader, stated in the public prints a few weeks ago that "labor was the only commodity which permitted the person using it to fix the price for it, and that he proposed in the new arrangements that were to be made that the laborer should fix the price of his labor, just as the manufacturer fixed the price of his manufactured product." This would seem a reasonable demand, yet John Mitchell ignored the fact that these men, occupying more than 5,000,000 of farms, were doing exactly what he claimed was being done only in the case of labor. The farmer seldom fixes the price of his produce; never in the case of many perishable products. It is fixed by the purchaser, and presumably based upon the conditions of demand and supply. If this were actually the case, no legitimate criticism could be made, but the facts are that in too many instances prices are fixed by those possessing superior advantages in the way of capital or intelligence, and without special reference to supply and demand. The producers on these millions of farms should have a share in these adjustments in proportion to their interests, and would be able to exercise a proper and legitimate influence if made familiar with the principles that are involved.

In the matter of transportation, too, it would seem that if economic conditions were properly adjusted more equitable terms for the distribution of the products of the farm would be provided. Transportation companies depend for their income to a greater degree upon the products of the farm, in both the raw and manufactured state, than upon the products of any other industry. The tonnage of corn, wheat, hay, and cotton greatly exceeds that of iron, coal, or oil; yet there are no rebates or cut rates offered the farmer. He is charged all the traffic will bear. One of the chief causes of the depression of agriculture in many sections of our country, and especially in our Eastern States, which are within a short distance of our large cities, is the cost of transportation. It is not possible to have perishable products transported in such a way as to enable them to reach the consumer at a cost and in a condition that would allow the producer to compete with products that are raised upon lands located at greater distances from points of consumption. Concrete examples of the influence of definite knowledge in changing conditions in many of these respects, I have no doubt, are familiar to all, as they are to be found in any State, and only illustrate the beneficent results of its broader dissemination.

The social conditions existing in many, if not all, farming communities also need to be improved. The advantages to be derived from education accrue only when the social nature of man is properly provided for. The farmer now is, in many instances, content to make money on the farm, but is not content with it as a home for his family. In fact, many use it as a means of securing a competence that would enable them to live elsewhere.

All of these problems, which affect, both directly and indirectly, the true progress of agriculture, and in a sense the stability of our Government, can be solved and will be solved in a satisfactory manner only when the essential principles which are involved are understood by the masses engaged in the work.

The agricultural colleges must recognize the gravity of these problems and give their moral support, not only, but should be the leaders in solving them. They must be in such close touch with the educational facilities of the various States as to make it possible for the boy on the farm to obtain an elementary knowledge of his business and likewise of its relation to all the other, in a sense, subordinate industries. I do not wish to be understood as saying that the colleges should interfere with things that do not concern them, but rather that they should take such an interest in all these problems as shall promote the proper education of the large number of men engaged in the work. In order that this may be partly met, many institutions have established short courses in agriculture, where it is possible for students to obtain a certain amount of knowledge, good as far as it goes and deserving of encouragement. The college should not be content with this, however, as it can not be regarded as the best and only thing they can do outside of their regular work; first, because it is not possible thus to reach all the farmers; second, because it is not true education and is not far-reaching enough to enable the student to master his opportunities like one who is surrounded from his earliest school days with an atmosphere of instruction, where not merely the proper general knowledge is supplied, but where the knowledge gained points constantly to the farm. The instruction, which is given by means of the farmers' institutes and which is now available in nearly every State in the Union, is to be highly commended and should receive the support of the college; yet also this work is not strictly educational; besides the institutes do not reach, as a rule, that class which is in the greatest need of advice and instruction. The agricultural press is a mighty force, and if properly directed is of very great service, yet this likewise is not an educational factor in its true sense. The skilled workman in other industrial lines does not regard his trade journal as a source of education, but rather as a source of information as to the progress that is being made in his profession. It is not possible by any of these means to acquire the sort of education which may come from the elementary or high schools. Such education will come only when those interested in the higher education will see to it that sound learning is provided in all grades.

The colleges also have a direct responsibility as to the kind and amount of work that shall be done by the experiment station, while on the other hand, the experiment stations have a direct responsibility in providing the colleges with accurate data for the instruction that shall be given in the various branches. The responsibility of the colleges is much greater, therefore, than that involved in the question of the number of hours that an experiment station officer shall teach in the college. This question is important, however, not only because the institutions are absolutely distinct, in so far as their incomes are concerned, but because the work of each is specifically prescribed in the laws establishing them. It is quite possible that an exact division of time and salary may be made, and yet the purpose of the appointment of the experiment-station officer be defeated simply because it is not a question of equivalents as to division of time and proportionate payment of salary. It is a fact that the progress made by the colleges is coincident in many instances with the establishment of the experiment station. This is no discredit to the college, nor is it to be regarded as a matter of great credit to the experiment stations. It was rather a matter of conditions, emphasizing more strongly than arguments the question of the interdependent relations of the two institutions, the one supplementing the work of the other. The colleges were not in a position to come in touch with the farmers; the experiment stations were, and hence the growth of the colleges has been, in a degree, proportionate to the effectiveness of the work of the experiment stations. The stations, like the college, have their work defined in the laws establishing them, and because the provisions of the law are capable of a broad interpretation, the character of the work that shall be done is left largely with the individual institutions.

The primary function of the experiment station is, however, not to teach, but to conduct experiments which shall secure and establish facts and principles that broaden the sciences upon which the practice of agriculture is built, and shall thus ultimately remove in large part the uncertainty now involved in its pursuit, which leads to the waste of much energy and involves vast financial losses. The work in question is broad and complex, and concerns not merely the raising of the crude products, and likewise their conversion into merchantable forms, but also the transformation of vegetable into animal products, and their further change into still finer forms. With the varying conditions that exist in the different States in respect to the soil, climate, and season, and location in reference to markets, the problems for study are almost innumerable, and thus call for broadly trained men who shall not only be capable of wisely selecting lines of investigation, but shall also be able to plan and carry on investigations in a highly scientific manner.

There may or may not be any marked significance in the first paragraph of the second section of the Hatch Act, which says "that it shall be the object and duty of said experiment stations to conduct original researches and verify experiments and publish results," etc. It is abundantly evident, however, from a careful study of the work that has been carried out by the various stations, that the lines of investigation specified in terms more or less exact have more largely occupied the attention of the stations than original researches. They have taken up the work of the various States that seemed to be of the most immediate importance, which, though not in all cases strictly scientific, has furnished a basis for broader work in the future, while at the same time it has been of direct service to many in modifying methods of farm practice and of indirect benefit, not only to the farmers in the State in which the station was established, but in many instances in all the States of the Union.

Prior to the establishment of the stations there was no opportunity for the farmers to see how science might be applied to practice, and the great progress that has been made in farming, particularly in the use of commercial fertilizers, the saving of farm manures, the improvement of crop rotations, the feeding of cattle for milk and beef, the improvement of pure breeds of animals, the introduction of new and better varieties of cereal and forage plants, the manufacture of dairy products, and the adoption of business methods, have been due to the work of the experiment stations in demonstrating by analysis and control experiments the economies that may be derived from the application of such science. The station's influence, therefore, has been thus far rather educational than investigational, though, as already pointed out, the former must necessarily precede the latter, and when the colleges shall have attained to their full influence the necessity for the educational side of experiment-station work will have largely disappeared.

In other words, the stations have passed through the various stages through which all new institutions must pass before reaching that degree of stability which will enable them to broaden their work, and, from the farmer's point of view, take up that which may seem to be of little immediate practical service. Many stations are now conducting original researches of a very important character, and of the greatest promise in the ultimate usefulness of the data obtained, and at no time in the history of the stations has there been a greater need for highly-trained men of the character above described. It is the manifest duty of this association, as representing both the colleges and the stations, to see to it that provision is made for the specific training of investigators; for, all things considered, our progress has been measured and its limits fixed by the men available, rather than by material equipment.

But when we compare the progress that has been made in the acquiring of new facts through original research, we find that we have not progressed very far. In the domain of chemistry the chief progress has been in the perfecting of methods of analysis and in the application of the facts already well known, rather than in the establishing of principles of fundamental importance. The same is largely true of the other sciences related to agriculture. Such new facts as have been gained have not contributed materially to the development of that particular science. Much has been learned of ways and means in themselves of great service, to be sure, yet these were hardly the result of deep scientific research.

The stations are confronted to-day, though perhaps in a less degree, with the same conditions that confronted them in their establishment in 1887, in reference to many problems, the solution of which is of the highest economic value. We daily witness large areas of our soils lying idle and unproductive because we do not know what to do with them. We are powerless to prevent losses of fertility from our soils because the causes of loss and means of prevention are unknown. We appreciate the importance of providing the crops with the right kinds and proportions of plant food, and yet see money and energy wasted because we are unable to give advice that shall be of service in conserving and making available the essential constituents. The farmers are subjected annually to stupendous losses of live stock because we can not correctly diagnose disease and suggest methods of prevention or provide a positive remedy. The depredations of pernicious insects and plant diseases still cause the farmers to groan in spirit, because suggested remedies are in many cases ineffective. I cite these facts, not in a spirit of criticism, nor for our discouragement, but rather that we may be incited to greater activity in providing for and promoting those lines of work which shall broaden the foundations upon which the science of agriculture rests. We are engaged in a great work, the importance of which in all its relations it is impossible to adequately express in words. It remains for us who have been so signally honored as to be thought worthy to participate in it to live up to the high ideals set for us in the beginning, the pursuit of which has resulted in broadening the influence and increasing the helpfulness of the institutions represented in this association.

At 10 o'clock p. m. the convention adjourned to meet at 9.30 o'clock a. m., November 15, 1905.

MORNING SESSION, WEDNESDAY, NOVEMBER 15, 1905.

The convention was called to order at 9.30 o'clock a. m. by the president, E. B. Voorhees, of New Jersey.

H. C. White, of Georgia, announced the order of business for the day recommended by the executive committee, which was accepted without discussion.

H. C. White also announced that, on account of death in his family, Prof. L. D. Harvey, of Menomonie, Wis., asked to be excused from presenting the paper on "The relation of the agricultural colleges to industrial education in its elementary and secondary phases," which he had agreed to prepare for this convention of the association.

On motion of Doctor White, the association extended to Professor Harvey the expression of its regret that he could not keep his engagement, and its sympathy in the sorrow that had come to him.

REPORT OF COMMITTEE ON METHODS OF TEACHING AGRICULTURE.

The report of the committee on this subject was read by A. C. True, as follows:

At the meeting of this association in Washington in 1903 there seemed to be a desire to have the committee on methods of teaching agriculture investigate and report on the feasibility of teaching agriculture in the rural schools. Your committee made such an investigation and embodied its results, along with suggestions on the nature and extent of such teaching, in a report presented at the Des Moines meeting. This report was published as Circular 60 of the Office of Experiment Stations, and later was embodied in the proceedings of this association. The first edition of Circular 60 (5,000 copies) was exhausted in less than six weeks, in another month the second edition of 5,000 was gone, and at the present time only 3,500 copies remain of an edition of 10,000 issued March 27. As a result of sending the circular to the State superintendents of education, requests were received to send it to several thousand county, township, and city superintendents of schools. The circular was frequently referred to and portions of it quoted by agricultural and educational journals, and that part of the report designated "Syllabus of Elementary Course in Agriculture" was embodied in the very important and comprehensive report of the committee of five of the National Educational Association on industrial education in schools for rural communities.

The widespread interest thus indicated in the teaching of agriculture in the public schools led your committee to continue its investigations along this line with a view of reporting on the availability of illustrative material and exercises for the use of teachers and pupils in school agriculture. The agricultural extension officers in a number of the land-grant colleges were consulted. Schools in which agriculture is being taught were visited, and the text-books and other literature prepared for the use of public schools were collected and studied. As a result of this work your committee has arrived at the conclusion that there is an abundance of suitable material with carefully prepared suggestions for its use in illustrating the principles upon which the science of agriculture is based. But this material is scattered through many text-books, bulletins, and circulars of information, and as a natural result the exercises lack cohesion. They are not arranged in progressive series and they are neither available nor suitable for general use in the public schools throughout the United States.

Furthermore, many of the best exercises are embodied in publications issued by agricultural colleges or State departments of education, and their distribution is limited by law to the States in which they are printed. Your committee is of the opinion, therefore, that this material should be brought together and subjected to a thorough sifting process. Unsuitable material should be discarded; exercises which are suitable for school use in their present form should be published with due credit to their authors; those needing revision should be worked over, new exercises should be prepared to fill in gaps, and finally all of this material should be pedagogically arranged, suitably illustrated, and published in such form that it can be used to supplement the text-book of agriculture in the public schools. There should also be a careful study of the apparatus and materials needed in connection with the exercises outlined, and a list of these and their probable cost should be published.

Considerable progress has been made during the past year in getting together material for a report on this subject such as your committee desires to present, but some time must necessarily elapse before it will be in form for publication. Your committee therefore proposes to negotiate with the Office of Experiment Stations to prepare such a report as has been suggested herewith and publish it for general distribution throughout the United States.

The committee proposes to continue its work during the next year in two lines: (1) A study of courses in agriculture for agricultural high schools and other secondary schools, and (2) the more detailed formulation and discussion of college courses in animal husbandry to supplement the general outline of courses in this subject already published.

A. C. TRUE,
T. F. HUNT,
H. T. FRENCH,
H. H. WING,
J. F. DUGGAR,
Committee.

H. T. FRENCH, of Idaho. Before this report is finally disposed of I would like to call upon Doctor True to give us some further statement as to the work of the Office of Experiment Stations in connection with this report and the former reports that have been made.

A. C. TRUE. The Office of Experiment Stations, as you all know, was established primarily to aid the experiment stations in various ways, and has naturally become a sort of clearing house for the experiment-station movement in this country. The fact that these stations were departments of the agricultural colleges, and that the work of the stations themselves was very intimately connected with the development of the courses of instruction in the agricultural colleges, naturally led the Office to take up, at the request of individuals and institutions, work relating more directly to agricultural education; and with the progress of the movement for agricultural education in a broader way, the Office has naturally broadened its work. This has been especially true since the formation by this association of the committee on methods of teaching agriculture, the director of that Office having been made a member of that committee.

This work has gone on until we have been drawn into connection with the general movement for agricultural education in such a way that the demands on us for work in different lines are so large that under present conditions the matter is somewhat of an embarrassment because we are not able to meet those demands. Through the action of this association and the work of the committee on methods of teaching, as well as the work that has been done in connection with the expositions, particularly the St. Louis Exposition, the Office has now a considerable number of publications on agricultural education, and it has become recognized in the country to a very considerable extent as an agency for the promotion of agricultural education. The result is that not only are the institutions represented in this association making appeals to us to aid in this direction, but we are getting appeals in the same way from other organizations, from the State and county superintendents of education, and a large number of teachers, as well as from organizations which represent the interest of the agricultural people in this matter. Now, if this work is to go on effectively, I think that we must have the cooperation of this association with reference to its development. At present the work is done as an incidental matter. There is no provision in the law expressly for such work, nor have we any organization for the work beyond the employment of one officer who gives a part of his time to the work, and represents it in the Office. I refer now to

Mr. Crosby, who is in charge especially of the matters relating to agricultural education, although the rest of the office force, so far as they can, assist in that work.

Now, it has seemed to me that if it is desirable that the Office should continue this work, and develop it according to the demand, we must have the work recognized by law, and must have some definite provision for it; and so I have asked the Secretary of Agriculture in making up his estimates this year to word the appropriation bill so as to provide for this work, and also to estimate a certain amount for it, and that he has done. The proposition is to add to that provision of the appropriation act which allows us to undertake work in connection with the farmers' institutes simply the words "and agricultural schools." It will then be recognized in the law that we are to work for the promotion of agricultural schools as well as the farmers' institutes. Of course the term "agricultural schools" we shall interpret broadly to include institutions that are engaged in instruction in agriculture. The amount asked for is $5,000, which it seems to me is a sufficiently modest sum for work of that kind if it is to be made at all efficient.

I think that in view of the interest in this matter that seems to be expressed here in a general way it is desirable that the association should understand just the situation. From our point of view it is certainly desirable that this matter should be in some way effectively brought to an issue and decided by Congress. I ought to say, perhaps, in this connection, that we have endeavored to manage this work in such a way as not in any way to interfere with the work that the Office has undertaken in other lines. You will perhaps remember that at some previous meeting—I do not remember whether at Des Moines or before that—the association expressed itself with reference to the extension of the work which the Office is doing on the Experiment Station Record, and that has been kept steadily in mind. We have received a small increase in our appropriation; I think last year we got about $2,500 more in the general appropriation than we had previously. And just as far as possible we are endeavoring to meet the desire of the association in matters relating to the Experiment Station Record. In order to make that publication more comprehensive and at the same time limit its work more distinctly to the lines of agricultural science, we have this year made a somewhat different arrangement of the departments and have increased the staff of the Record so as to have editors specifically for the departments of rural engineering, rural economics, and agricultural education. Those matters had been previously treated of more or less in the Record, but now they will receive more space and matters relating to them will be more definitely followed. So that we are endeavoring not to neglect the work for which we were primarily established. But this matter of agricultural education is particularly pressing just now, and if the work is to be put on a definite basis we need the cooperation and support of the friends of agricultural education wherever we can find them.

The report was accepted.

REPORT OF COMMITTEE ON GRADUATE STUDY.

A report from the committee on this subject was read by L. H. Bailey, chairman, as follows:

The first graduate school of agriculture, held in the summer of 1902, was conducted under the auspices of the Ohio State University and with the cooperation of the United States Department of Agriculture and the Association of American Agricultural Colleges and Experiment Stations. The success of that school has led the Association of American Agricultural Colleges and Experiment Stations to instruct its committee on graduate study to consider the question of holding other schools of similar character. At its meeting in Des Moines the association reaffirmed its conviction that a graduate school of agriculture is a desirable enterprise to be conducted in the summer at different colleges of agriculture in rotation, and expressed its desire that this school be held every two years.

The committee on graduate study was empowered to determine where such schools shall be held, and also to request each agricultural college to contribute the sum of, say, $25 annually to aid in the maintenance of such school. The committee reports that arrangements have been concluded whereby the school is to be held at the University of Illinois in the summer of 1906. It has also asked each of the agricultural colleges whether it could contribute $25 each year in aid of a graduate school. Affirmative responses have been received from 27 institutions, and negative responses from 15. Four of the institutions have expressed doubt as to their ability to contribute, and 3 have not responded. Omitting the University of Illinois, at which the forthcoming school is to be held, there remain 26 positive affirmative replies, making an annual assured contribution at this time of $650, or $1,300 for the biennium.

Your committee finds itself without definite powers in respect to the graduate school beyond the two items of business mentioned above. The nature of the powers delegated to this committee will determine the attitude of the association toward the graduate school, and the measure of responsibility that it desires to assume. Your committee believes that a graduate school is exceedingly important for the purpose of aiding the officers in colleges and experiment stations in keeping in touch with current progress, of concreting and harmonizing the work of these institutions, of developing friendships, and of inspiring enthusiasm. It believes that the maintaining of a graduate school should be a regular and continuing work of this association. Your committee therefore makes the following propositions for your consideration:

(*a*) The Graduate School of Agriculture is an institution of this association.

(*b*) It follows, therefore, that the policy and method of the school are to be determined by the association, and that the institution at which the school is held in any year is to be the agent of this association.

If these propositions are adopted, then the committee on graduate study (or some other committee created by the association) must be empowered to provide for the financial and pedagogical policies and conduct of the school. The committee recommends that:

(1) The moneys contributed by the different institutions in aid of the school shall be paid to the treasurer of this association and by him be paid over to the institution at which the school is held.

(2) The expenditures of these moneys shall be with the advice and consent of the committee on graduate study.

(3) The institution at which the school is held be requested to make to this association, for the information of the association and of such institutions as may care to conduct such a school, a statement of the expenditures in the interest of the school, not only of such funds as are derived from contributions, but also from fees and appropriations by the institution itself.

(4) The committee on graduate study, by and with the concurrence of the president of the institution at which the school is held, shall choose a dean of such school, and shall, either through the dean or otherwise, and with the concurrence of the institution, choose the faculty and determine the course of study.

(5) All local arrangements and all work of publicity lie with the institution holding the school.

(6) The committee be empowered to solicit funds from experiment stations as well as from colleges, when such stations are under management separate from the colleges, and also from State departments of agriculture and other organizations if it should seem wise to do so.

L. H. Bailey,
M. H. Buckham,
A. C. True.
W. O. Thompson,
B. Ayres.
Committee.

On motion of the chairman of the executive committee, the discussion of the report was proceeded with at once.

L. H. Bailey, of New York. There are two fundamental propositions which should be discussed, I think, before we proceed to the details of the organization and conduct of the proposed school. The first is that the graduate school of agriculture is an institution of this association; that this association is responsible for it; that it is the creature of this organization. If this be true, it follows, therefore, that the policy and the method of the school are to be determined by the association, and that the institution at which the school is held in any year is to be the agent of this association.

The financial maintenance of this school would come from three sources, so far as the committee now foresees. In the first place from the contributions by the colleges, and, in the second place, from the fees. At the graduate school at Columbus three years ago the fees were placed at $6, for the reason that other fees in other summer school work were placed at that. The committee believes that a fee of $10 would be fair and reasonable. At the Ohio school there were 75 matriculants. We should expect there would be 100 at a succeeding school, and at $10 apiece that would make $1,000, the remainder of the fund to be contributed by the institution that holds the school. The committee feels that some maximum limit might be placed on the cost of the graduate school. That maximum limit has not been fixed nor definitely discussed. It has been suggested that $4,000 might be the maximum.

I think that the association should assume financial responsibility only so far as its contributions are concerned. The contributions paid into the treasury of this association become the contributions of the association. But the committee feels that the financial responsibility of this association does not extend beyond the contributions.

The reason for the provision for the biennial session is that this association at Des Moines expressed its opinion that the graduate schools should be held every two years. The committee therefore worked upon that instruction. I think the committee, however, is unanimous in the feeling that this is frequent enough, and that a school could not possibly be maintained every year at the high pitch and grade at which it is desirable to maintain it.

The next proposition is merely a corollary of this, or at least a consequence of this, for it follows that the policy and method of the school are to be determined by the association, and that the institution at which the school is held in any year is to be the agent of the association.

After further discussion by E. Davenport, of Illinois; D. B. Purinton, of West Virginia, and E. A. Bryan, of Washington, a motion made by G. T. Winston, of North Carolina, that the report of the committee as a whole be adopted by the association, and that the committee be authorized and instructed to proceed to organization of the graduate school for the year 1906, according to the lines laid down in the report, was agreed to.

Report of Committee on Pure-Food Legislation.

A report from the committee on this subject was presented by the chairman, W. A. Withers, of North Carolina, as follows:

During the past year Maine and New Hampshire have enacted pure-food laws. Missouri and Wyoming have each appointed a food and dairy commissioner to whom is intrusted the execution of pure-food laws. Kansas has made a beginning by authorizing the board of health to collect samples and the professor of chemistry in the State university to make analyses of the same; but no appropriation for the work has been made. Indiana has made an appropriation and has established a laboratory, and by these means will enforce existing laws. In North Dakota and Idaho there has been a strengthening of existing laws. In other States existing laws have been amended without any very apparent gain. But in no State has any pure-food law been repealed except by the enactment of new laws.

Progress has been made in the different States, therefore, (1) by establishing a food control in States previously without it, (2) by the creation of machinery, or by making an appropriation for rendering existing laws effective, (3) by enacting laws without appropriations and making the work in so far as it is done a gratuity, and (4) by amendments which tend to strengthen existing laws or to secure greater uniformity.

The results which have attended the inspection by the United States Department of Agriculture of imported foods under existing laws of Congress illustrate the good effects which would follow the enactment of a law regulating interstate commerce in adulterated and misbranded foods, beverages, and drugs. It was thought in some quarters that this inspection would hinder or diminish foreign commerce in food products. The experience of two years of inspection, however, has shown that this fear is groundless. On the contrary, trade in inspected products has greatly increased. Purchasers, feeling that imported goods, such as olive oil, etc., have been inspected and are pure, are buying in larger quantities than ever before. This confidence of the public in the character of imported goods will be extended to those of domestic origin subject to interstate commerce, when a national law regulating interstate commerce is passed and enforced.

Such a law will be of immense advantage also in urging to uniformity the laws and regulations of the various States, thus relieving manufacturers of a great deal of annoyance, without in any way diminishing the protection afforded to the consumer.

Your committee, therefore, respectfully urges the association to take such action as will look to the indorsement of a pure-food measure, its introduction to Congress, and its enactment in law.

Messrs. Wheeler, Patterson, and Withers ask to be relieved of further service upon this committee, as their work is not connected with the food control.

W. A. WITHERS,
H. J. PATTERSON,
H. J. WHEELER,
Committee.

INSTRUCTIONS TO THE EXECUTIVE COMMITTEE REGARDING CONGRESSIONAL LEGISLATION.

The following recommendation of the executive committee was laid before the convention for consideration by the chairman of the committee, H. C. White:

Your committee submits to the association, in view of the efforts which will be required in connection with the proposition which will be made to increase the appropriation to the experiment stations, whether it would not be wise to withhold for the present specific instructions to your executive committee in connection with the mining school bill, leaving the committee free to concentrate its efforts to secure the passage of the Adams bill, giving, of course, to the mining school bill, if introduced, such support as may be practicable or conditions justify.

H. C. WHITE, of Georgia. In connection with that recommendation, the resolution offered by President Atherton (p. 28) covers the case largely, and the executive committee reports back this resolution for consideration at this time with an amendment. The recommendation of President Atherton, with the amendment by the executive committee, reads as follows:

Resolved, That the executive committee be, and hereby is, instructed to use its best efforts to promote the passage of the Adams bill; and

Resolved, That this association hereby reindorses the Mondell bill and advises the executive committee to give such assistance to its passage as, in its judgment, may be advisable and as circumstances may justify.

The adoption of this resolution would be substantially the adoption of the recommendation of the executive committee. If the association should continue to give instructions to its executive committee to urge the passage of specific bills, as, for example, a bill known as the "Adams bill," a bill known as the "Mondell bill," a bill known as the "Hepburn bill,—which you have just indorsed—a bill in connection with forestry, and so forth, that would scatter the efforts of the executive committee to such an exent that they would be futile in all cases probably. Now, to avoid minimizing the influence of the association your committee has suggested that you consider the propriety of restricting these instructions to the executive committee, asking it to concentrate its efforts on some particular measure. That is the question now, whether it should be the policy of the association to restrict its instructions to the executive committee so as to enable the committee to concentrate its efforts on some line of legislation, and that we understand to be the effect of President Atherton's resolutions that it is the sense of the association that the efforts of the committee be concentrated.

W. O. THOMPSON, of Ohio. I do not understand that the executive committee is asking us to concentrate on the Mondell bill or any other bill, but they are asking us whether or not this association should not say to them, "We desire you to concentrate your efforts upon some specific thing in the hope of success." The question before the association, if I understand it, is now really on the general policy, whether we shall aim for one thing or go out for everything in sight; and the judgment of the executive committee seems to be that if we go out for everything in sight we will come back with nothing; whereas if we go for one thing we may get it, or we may not. Now, there may be a difference of opinion on what we should go for, but the important issue is that we should concentrate our efforts upon some particular thing.

E. DAVENPORT, of Illinois. My view is that we should not bind this committee down too closely. If we instruct the committee to do one thing, it may be found to be something that can not be done. There are three or four pieces of legislation that we want to see adopted as soon as possible, and it seems to me that if we surround our committee with ironclad instructions each year, those instructions may stand in the way of achieving some other thing that might be brought about. If a particular bill is now in favorable form for passage, at the coming session of Congress, and we think that is most likely to pass, and we instruct our committee to work for that, it may very well be that that bill can not pass, and that some other bill may pass. Therefore I am in favor of intrusting our executive committee with a considerable degree of discretion, allowing them to use their own judgment as to where to put the pressure and the work when the time comes.

G. T. WINSTON, of North Carolina. I thought there were some specific recommendations made by the executive committee in regard to the Adams bill, and then in regard to the Mondell bill. If it is only the general recommendation that we should concentrate our efforts, I do not desire to ask for a division of the vote on the question. If, however, we are to vote for the Mondell bill, I would like more information as to the present condition of that bill, for I am frank to say that I am not satisfied with that bill as I last saw it, and I do not think that the association would be satisfied with that bill if it fully understood. It seems to me that the time has come for this association to assert itself in protecting the interests of the colleges and the kind of education which this association, as I understand it, was formed to protect and promote. I think there is danger that the great interests and the great ideals of education represented by this association are going to be interfered with and checked and obstructed by other influences and by other interests and by other ideals of education. If a bill for the establishment of mining schools in connection with land-grant colleges is to be so framed that institutions which have no mining departments are able to secure the benefits of the appropriations, and so divert them from their proper channels, why can not the same thing be done with any other school—a forestry school for instance? And, then, why not go back and deal with appropriations and institutions already existing? I see no reason why this should not be done. It is the principle that I oppose.

I hope that this association will not indorse the Mondell bill in its present shape, and whether we get it or do not get it, let us stand upon a principle.

H. C. White. The motion before the house is not on the question of indorsing one thing or another. The motion before the house is on the question whether the convention will declare its policy as to concentration. The resolutions of Doctor Atherton, which have come in subsequently, provide for specific instructions in regard to the Adams bill and general advice in regard to the Mondell bill. Those resolutions, however, are not now before the convention. The question is now on the motion of Dean Davenport that the recommendation of the executive committee be adopted, and that it shall be the policy of the executive committee to concentrate their efforts rather than diffuse them.

J. K. Patterson, of Kentucky. I have no scruples whatever about going before the Congress of the United States and asking for what our agricultural and mechanical colleges need. They get the money from the people, and it is their function to disburse to the best advantage this money for the benefit of the Republic. I have a perfect right, and this association has a perfect right, to go before Congress and ask whatever it wants and whatever it needs, and I do not think that it need have any compunction because of States' rights or any other sort of rights. The money in the Public Treasury belongs to the people, and if we can induce Congress to believe that they are making a proper use of the means at their disposal in fostering and supporting these land-grant colleges along the lines originally indicated in the organic act, that is all right. Now, I am interested in the passage of this Adams bill. I believe that the experiment stations ought to be strengthened; and I do not believe that we are in any danger of asking for too much in this direction. But I am equally interested in the passage of a measure of some kind that will give strength to the other side of the provision made for the establishment of these colleges, namely, in the direction of mines and mining, which seems to me to be a legitimate outcome, a legitimate corollary, from the original establishment of colleges for the study of agriculture and instruction in the mechanic arts.

Now, every State in the Union is interested in the passage of a mining bill. We are interested in it, and have made repeated efforts to get it through. It is going to come up again this time, whether we will or not. If it is not introduced under the auspices of this association, it will be under the auspices of one or two other associations, and they are working diligently to accomplish their end. Some of us who attended the meetings of the Association of State Universities the other day were also allowed to attend a meeting of the Mining Association. The Mondell bill was presented in a modified form, and after the criticisms of President Atherton and others it was agreed that that was a bill which not only harmonized the interests of this association, but also harmonized the interests of this association with other interests outside of it.

Now, whether we will or not, a measure is going to be introduced, and if it is not introduced with our cooperation, and if in consequence of our opposition we take no part in the movement, if we even are neutral in the matter, our interests may suffer. This bill was believed, after it was recast, to be acceptable to all concerned. It was accepted by the Mining Association; it was accepted unanimously by the presidents of the colleges and universities outside of this association who were present yesterday and who adjourned yesterday. It seems to me that it would be folly for us to withhold our active cooperation in this matter. We may not be the introducers of the bill, but if that bill be introduced by other parties, as it certainly will be by these two other associations, it is just possible if we give it the cold shoulder, or betray an attitude of neutrality—whether active or not—it will be passed to our detriment. We ought not to be placed in that attitude. If we believe that that bill sufficiently guards our interests, if it is not in any important sense antagonistic to our interests, though we do not get all we would otherwise get if it was introduced by ourselves and there was nobody else to thwart us, then we ought to give it our hearty cooperation and our effective cooperation.

Now every State in the Union is interested in this matter. Even Maine is interested in it; and Florida is interested; and a great many of those States which have infant mining industries now are interested in it. The State of Kentucky is especially interested in it, and we expect to work earnestly in conjunction with whoever introduces this bill, believing that in whatever shape it passes now we are anxious to cooperate as beneficiaries, to cooperate in placing it upon the statute books of these United States. I believe that ought to be the attitude of every one of our organizaions. If we can not get all we want, take all we can get. Half a loaf is better than no bread. And if there are antagonistic interests which come into the arena, concede a little now, in order that you may be able to get your opponents to concede a little on the other side, and bye and bye a bill will be produced, some such bill as this that was read the other night and was submitted to these associations, which will benefit very largely all the interests. I scrutinized that bill pretty carefully, and I believe that in the main the agricultural and mechanical colleges which compose this organization will be benefited. This is a matter of extreme interest to us and to all the institutions in the nation. The agricultural interests are now and for a long time will be predominant; but there are other interests that are coming to the front very largely and which will in the end be potent rivals of the agricultural production of the United States of America. More than 100,000,000 pounds of copper are mined here every year and sent abroad to be manufactured abroad and to come back here for us to buy. Why might not these industries be developed to such an extent as to enable us to utilize them at home? There are billions of tons of coal that only await the industrial energy and intelligence of the mining engineer to be brought to the surface and to add immensely to the wealth of this country; in iron and copper and silver and gold there are billions of tons in the bowels of the earth that are only awaiting their development. Now, how can this be better accomplished than by adding to the facilities of those mechanical branches of learning that are now taught in connection with these land-grant colleges, placing this mining instruction and education right there, so that, by cooperation with these other elements, provision for which is made along the scientific lines, the greatest amount of energy may be brought to bear, thus bringing together a concentration of capital and a diffusion of labor that will yield the greatest possible results? Just in connection with these agricultural and mechanical colleges ought these schools of mines to be established; and this Mondell bill, I seriously and earnestly believe to be instrumental in bringing about that same result. If we attempt to bring it about ourselves and ignore the cooperation of each other's interests, we shall fail. If the Association of State Mining Schools attempts to do it without the cooperation of the other two associations, they will fail. And if the third one attempts to carry that measure through Congress, they will fail, whether through our opposition or our apathy. But when we all put our shoulders to the wheel, the appropriation will be secured, and in nine cases out of ten it will go where it ought to go, namely, to the agricultural and mechanical colleges.

E. Davenport. I have written out a resolution which expresses the thought that I had in mind, and I offer it as carrying out the recommendation of the executive committee and as a substitute for the resolution of President Atherton. It reads:

In view of the fact that this association has indorsed a number of plans looking to appropriations from Congress, and is likely to indorse others of similar character; Therefore be it

Resolved, That its executive committee be instructed to safeguard the interests of all these measures at every point, but to concentrate its efforts at any particular session upon the bill or bills which may seem to be in the most favorable condition for passage.

The resolution was adopted, and, after some further discussion, the resolution of President Atherton, as amended by the executive committee, was laid on the table.

G. T. Winston offered the following resolution and asked its immediate consideration, which was agreed to by the executive committee:

Resolved, That the executive committee be instructed to secure, if possible, such changes in the Mondell bill as will apply the funds appropriated thereby according to the previous policy of Congress in establishing and developing colleges for industrial education, such policy being outlined in the Morrill bill, the supplemental Morrill bill and the Hatch Act.

President Winston said, in support of the resolution:

The purpose of this resolution is that, if the committee can do it, they should get us back again the Mondell bill as originally introduced in Congress. It was then acceptable to the Association of Mining Schools and this association, and it was acceptable to everybody except the State universities. My motion is simply that we ask a continuance of the policy of the National Government as outlined in the three bills I have mentioned—the Morrill bill, the supplemental Morrill bill and the Hatch Act. We have those three laws already passed by the National Government, and my motion is that we ask Congress not to change the policy established by them. It is nothing new I am asking for; I am resisting something new, and something which will be the entering wedge in controlling any future appropriations that the National Government may make.

At the suggestion of President Thompson, President Winston amended his resolution to read as follows:

Resolved, That the executive committee be instructed to request Congress to continue the policy that it has adopted in the Morrill bill, the supplemental Morrill bill, and the Hatch Act, according to the lines there laid down.

The question upon the motion as amended was taken, and the motion was agreed to.

CLAIMS OF THE EXPERIMENT STATIONS TO THE CONSIDERATION OF CONGRESS.

H. C. WHITE. The second recommendation of the executive committee is:

It is recommended that the association instruct the executive committee to take appropriate action to secure, if practicable, the presentation of the claims of the experiment stations to the proper support and consideration of Congress at the next session of that body.

This recommendation of the executive committee was adopted.

STANDING COMMITTEES.

H. C. WHITE. The third and last recommendation of the executive committee is in regard to the matter of the standing committees of the association. The executive committee offers the following resolution and recommendations:

Resolved, That all matters affecting the relations of the association to the Government departments and to National legislation be assigned to the executive committee or to special committees raised from time to time to meet special exigencies, and that matters relating to the work of the association itself be assigned to the standing committees of the association.

It is recommended (1) that the standing committees of the association be as follows:

(a) On bibliography.
(b) On methods of teaching in the land-grant colleges.

(c) On graduate study.
(d) On extension work.
(e) On experiment station organization and policy.

(2) That each committee shall consist of five members.

(3) That the committees shall be appointed and announced by the president of the association at the concluding session of each annual convention.

(4) That the members of the committees, when practicable and unless the president for good cause shall otherwise determine, shall be selected from those in attendance upon the convention at which the committees were appointed.

(5) That vacancies arising between conventions shall be filled by the committee in which the vacancy has occurred.

After considerable discussion the resolution offered by the committee was adopted, and their recommendations were referred to a special committee consisting of A. C. True, L. H. Bailey, E. A. Bryan, W. E. Stone, and C. D. Woods to report during the convention. (For report of this committee see p. 50.)

DEPARTMENT OF AGRICULTURAL EDUCATION IN THE NATIONAL EDUCATIONAL ASSOCIATION.

The chairman of the executive committee reported the following resolution, offered by K. L. Butterfield, of Rhode Island:

Whereas this association believes that the questions involved in the general and the technical education of the rural people are of sufficient importance to warrant special recognition in the great gatherings of American educators: Therefore be it

Resolved, That our executive committee be hereby instructed to take such steps as they may consider necessary in an endeavor to secure the consent of the National Educational Association to add to its list of special departments a department or departments on rural and agricultural education.

K. L. BUTTERFIELD. I do not know that this resolution needs any extended explanation. It has been presented here after consultation with members who are in touch with the National Educational Association. It seems to me that while the suggestion might come from that association that it has already, perhaps, a sufficient or too great number of departments, the fact remains that the National Educational Association has not yet recognized agricultural education in a sufficient degree. It is true that the subject of rural schools has been taken up in the last eight or ten years, and well discussed by that association. It is also true that the recent report of the committee on industrial education is a good piece of work; but the department that we stand for has not been, to my mind, definitely and sufficiently recognized by the National Educational Association. It happens that the National Educational Association has announced that it is to ask for a bill of incorporation from the next Congress, and in that bill there are specified seventeen departments already existing.

Now, it seems to me that the work of agricultural education has attained sufficient dignity to demand from the body of our educators a department. It is true that these things may be taken up in a general session, but, as a matter of fact, they will not be sufficiently discussed. It also remains true that if we had a department of this sort, we, who are members of this association, would be charged with the responsibility of supporting it; but it seems to me that would be wholly a good thing, that we ought to be in closer touch than we are with that association, and they ought to recognize more fully the relations of our special lines of work to the general educational movement of the day. And this matter leaves the method entirely with our executive committee, to treat it as they see fit, to call it what they see fit, and, in fact, to engage as they see fit with the National Educational Association.

On motion the resolution offered by President Butterfield was adopted.

Hon. William T. Harris, Commissioner of Education, being introduced, spoke as follows:

ADDRESS OF HON. WILLIAM T. HARRIS, COMMISSIONER OF EDUCATION.

Gentlemen, I thank you for this indication that you like to hear or see me for a moment and hear a word from me, and I would like to put in that word right here on the subject that has now been brought up before you. The National Educational Association has one large general meeting, as you do, and it has ever so many departments and may have ever so many more. Anyone who is interested in any line of education in one of these departments may, if he can get together twenty or thirty or forty or fifty persons who wish to pursue his special line of investigation, have a department formed for them, and the general executive committee of the association, in going from one city to another year by year, make arrangements for them and take care of all the business part of it, so that all that these particular specialists who form a new group need to do is to meet at that room which is provided for them on the dates specified. I think, myself, it is really most important that agriculture—that is, agricultural instruction—in the elementary schools, and perhaps also in the secondary schools, should be provided for in the National Educational Association, and if President Butterfield should be charged with that matter and bring it before the association it would be very easy to get such a department established, and the movement would prove fruitful to the National Educational Association itself, because it would get hold of and meet a certain desire and impulse that is moving throughout the country to have agriculture recognized. I suppose there are various crude attempts all over the country to introduce instruction in agriculture. Sometimes that movement stops at the vestibule. When you and I, Mr. Chairman, were little boys agricultural instruction in this country began at the vestibule, and began by teaching a little book chemistry and a little Latin, and things of that kind, and never got beyond that. Of course the great point now in our day is that we push beyond the vestibule, and sometimes we push so far that we forget that there is any vestibule and that there ought to be one. Now is the time when there ought to be a department devoted to agriculture in the National Educational Association. The National Educational Association collects at its meetings from 20,00 to 35,000 people sometimes. We had one meeting attended by 36,000 people in Boston last year; a very large gathering, and a great market fair, as it were, of education of all kinds.

Once I was interested in getting up a series of round-table discussions; it is amusing to think of it, and perhaps some of you here may remember the result of it. We had discussions at Saratoga, and we had them on such transcendental subjects as Schopenhauer and his pupils in Germany and their pessimistic discussions. You could have such discussions in round tables, but not on the farm.

But agriculture should be brought up every year at the educational association and a harvest of the thoughts be gathered there. That was the object of establishing this great market fair of the National Educational Association—that each one should bring his contribution to it, and find other persons who had been working along those lines; and each one taking what is brought by the others, each goes home richer by many things than the one thing that he brought. That is what will happen in the National Educational Association if this section is formed. There will be a gathering together of results and a reaping of them, and it will give the agricultural colleges all over the country and the State universities which deal with agriculture a part and place. Every university, of course, every year finds certain lines on which it wishes it could influence the elementary schools, and each one examines the educational instruction in the elementary schools to find something that might be adopted in his own State. There are thousands and thousands, sometimes as many as a hundred thousand programmes of the annual meeting of the association circulated all over the country before the meeting. But I need not tell you about the National Educational Association, except that it has $150,000 at interest, income to be appropriated to printing its proceedings, so that a good paper on any subject always gets printed, and it is possible to get these papers reprinted sometimes, as the matter is electrotyped.

STATISTICAL WORK OF THE U. S. DEPARTMENT OF AGRICULTURE.

H. C. WHITE, of Georgia. The executive committee reports the resolution offered by Director Waters, of Missouri (p. 29), and recommends its passage in the following amended form:

Whereas the collection and publication of accurate agricultural statistics is of importance and of great assistance to the land-grant colleges in connection with the teaching of agricultural economics: Therefore, be it

Resolved, That it is the sense of the American Association of Agricultural Colleges and Experiment Stations that the United States Department of Agriculture should continue the collection and dissemination of information and statistics with respect to the condition and yield of farm crops.

The resolution was adopted as amended.

REPORT OF COMMITTEE ON COLLEGE AND STATION EXHIBIT AT THE ST. LOUIS EXPOSITION.

W. H. JORDAN, of New York. Your committee wishes to present you with a document which covers the history of the life of that committee, and to call to your attention the fact that the initiative of the effort to secure the exhibit at St. Louis began four years ago, so that the work of your committee covers four years from the initiation of the effort to the final act. Our object in having this report prepared (and we owe many thanks to the Office of Experiment Stations for the real labor of the preparation of the report), covering, as it does, a complete history of what the committee did, is to put it on file, so that it may be available to those who have any such burden in the future, a complete record of what was done at the St. Louis Exposition, and what steps and machinery were used that would pertain to similar efforts.

I only wish to make one or two remarks on this. In the first place, we did not spend all our money. The main reason for expending only about $90,000 out of the $100,000 that we had was that we were unable to inaugurate, on so extensive a basis as we desired, what was known as the "outside exhibit."

A. C. TRUE. I take it that the acceptance of this report will hardly include the ordinary understanding that it is to be made a part of the proceedings of this meeting. We have to deal with the printing of these in the Department of Agriculture, and it is, therefore, of interest to me. I would suggest that it be received with the understanding that it is to be placed on file in the Office of Experiment Stations, where it will be available to all future committees who have to deal with such matters. I have considerable doubt whether, as Director of the Office of Experiment Stations, I could recommend the publication of the report in its present form. There are many details in it which would be of very little use except to a committee dealing with the matter. There is absolutely no provision in law for the printing by the Government of any report of the St. Louis Exposition. The only thing that the Government Board has undertaken, as I understand it, is the preparation of a catalogue, more or less extensive, of the exhibit as a whole. If that is to be printed at all it will have to be by special act of Congress. In the case of the Chicago exhibit, if I remember correctly, no report was ever printed by the Government. In the cases of some of the foreign expositions quite extensive reports have been printed. I might say that a somewhat extended report of this exhibit, with illustrations, has been published by the Office of Experiment Stations in its report for the year 1904, and, as far as I am aware, that covers everything that the association desires to have that can be gotten out of this report.

JAMES K. PATTERSON, of Kentucky. That report, I have no doubt, contains a great deal of valuable matter. I doubt whether any appreciable part of the contents is known to any member of this association outside of the committee of the association that had charge of it. I doubt whether one-tenth of it is known to the members who had charge of it. From that point of view, it seems to me publicity should be given to it. It seems to me that was a very important exhibit. It was not only agricultural, but also mechanical, and I have no doubt there are hundreds and hundreds of persons throughout the country who would read that report with interest. I believe that every member of the association into whose hands it might come would read it and would profit by it. It seems to me that a proper appeal made to the National Congress by the executive committee of this body, or by any other properly constituted committee representing this body, would obtain recognition from that body and enable us to give it to the world.

A motion that the report be received and placed on file in the office of Experiment Stations was agreed to.

On motion of W. D. Gibbs, of New Hampshire, a vote of thanks was extended to the committee whose duty it was to arrange the exhibit at St. Louis.

RESOLUTION REGARDING NATIONAL GRANGE.

William P. Brooks, of Massachusetts, offered a resolution, as follows:

Resolved, That the Association of American Agricultural Colleges and Experiment Stations extends to the National Grange of the Patrons of Husbandry assembling to-day at Atlantic City, N. J., its cordial greetings and best wishes for a gathering which shall be fruitful in good work.

The resolution was adopted, and the secretary was instructed to transmit it to the meeting of the National Grange by telegraph.

Thereupon the convention adjourned until 8.30 o'clock p. m.

EVENING SESSION, WEDNESDAY, NOVEMBER 15, 1905.

STANDING COMMITTEES.

A. C. True, of Washington, D. C., presented the report of the special committee on standing committees, as follows:

The special committee on standing committees submits the following recommendations:

(1) That the standing committees of the association be as follows:
  (*a*) On instruction in agriculture.
  (*b*) On graduate study.
  (*c*) On extension work.
  (*d*) On experiment-station organization and policy.

(2) That each committee shall consist of six members. When the committee is first appointed two members shall be appointed for one year, two members for two years, and two members for three years. Members appointed therafter shall serve for three years, except that members appointed to fill vacancies shall serve only during the unexpired remainder of the terms of the members whose places they take.

(3) That the committee shall be appointed and announced by the president of the association at the concluding session of each annual convention.

(4) That the members of the committees, when practicable and unless the president for good cause shall otherwise determine, shall be selected from those in attendance upon the convention at which the appointments are made.

(5) That vacancies arising between conventions shall be filled by the committee in which the vacancy occurs.

For the committee:

A. C. TRUE, *Chairman.*

A. C. TRUE. This report follows quite closely the recommendations of the executive committee with regard to this matter, the only changes being that the committee on bibliography is dropped, as I understand was agreed upon this forenoon by the association. The committee on instruction in agriculture is substituted for the one on teaching in land-grant colleges. This is done with the idea that this committee on instruction in agriculture will consider in a broad way the courses of instruction in agricultural colleges and schools preparatory thereto, and in that way will take in probably all the subjects which, under present conditions, are likely to be considered by the committee.

The work of the committee on extension work would then relate to such matters as farmers' institutes, correspondence courses, clubs of boys and girls, and other matters ordinarily included in such work.

Another change made is in the extension of the number of members in each committee from five to six. This was done in order to make it somewhat easier to subdivide the committees into subcommittees for special purposes, and also to make possible the other provision inserted, that these members be divided into classes, so that two new members might be appointed each year, and the older members would hold over, making the term of service, in all, three years.

The third and fourth provisions are identical with those of the executive committee, and the fifth is also the same, and in any case is hardly necessary, perhaps, because it follows the standing rule of order of the association.

The report was adopted.

RESOLUTION REGARDING PROF. W. O. ATWATER.

C. D. WOODS, of Maine. Those of us who have been familiar with this association from its earlier days remember how much we owe to the interest in the first meetings, and the later meetings, as well, of Professor Atwater, who was the first director of an experiment station, and the first Director of the Office of Experiment Stations. As I presume it is known to most of those here, Professor Atwater was stricken more than a year ago, and is now lingering at his home in Middletown. With the consent of the executive committee I have drawn, and now present, a short note of sympathy which I would like to present at this time, the executive committee favoring its adoption, and to ask that the secretary be instructed to report it to Mrs. Atwater:

> The Association of American Agricultural Colleges and Experiment Stations regrets that illness prevents Professor Atwater from being present at this meeting, and as he was the first director of an American agricultural experiment station, and the first Director of the Office of Experiment Stations, and as in other ways he has done much for the work, and will always be remembered, the association extends its sympathy, and all wish that he may soon be much improved in health.

The resolution was adopted, and the secretary was directed to transmit the same to Mrs. Atwater.

OFFICERS OF SECTIONS AND MEMBERS OF EXECUTIVE COMMITTEE.

K. L. Butterfield, of Rhode Island, reported that the college section presented for members of the executive committee H. C. White, of Georgia; J. L. Snyder, of Michigan; and L. H. Bailey, of New York; for chairman of section, C. R. Van Hise, of Wisconsin; for secretary of section, H. C. Price, of Ohio; for programme committee, the chairman and secretary of the section.

The report was accepted.

M. A. Scovell, of Kentucky, for the experiment station section, reported as follows: For chairman of section, B. C. Buffum, of Wyoming; for secretary of section, M. A. Scovell, of Kentucky; for members of the executive committee, W. H. Jordan, of New York, and C. F. Curtiss, of Iowa; for programme committee, H. P. Armsby, of Pennsylvania; C. F. Curtiss, of Iowa; M. A. Scovell, of Kentucky.

The report was accepted.

ANIMAL AND PLANT BREEDING—THE AMERICAN BREEDERS' ASSOCIATION.

C. F. Curtiss, of Iowa, presented the report of the committee on animal and plant breeding, as follows:

Your committee on the American Breeders' Association submits the following report:

The American Breeders' Association held its first annual meeting at Champaign, Ill., February 1–3, 1905, as the guest of the Agricultural College of the University of Illinois and of various State live stock and agricultural associations. The meeting was well attended, great interest was taken in all sessions, and a splendid three days' programme was carried out.

The council has recently issued the first annual report, including, with the papers and discussions, a classified directory of members, showing the lines of scientific interest with which each member is concerned and the lines of pure-bred live stock and pure-bred seeds produced. There are now about 600 members, and the association is without debt.

There is need of a fund to place the association on a permanent basis. The members of the Association of Agricultural Colleges and Experiment Stations and others interested are urged to aid in their respective States in increasing the membership and in other ways to help build up this organization. Persons who have wealth to devote to public uses could serve a most important public purpose by providing a suitable endowment for this promising association.

The second annual meeting has been called to meet at Lincoln, Nebr., as the guest of the College of Agriculture of the University of Nebraska and of the several State societies of live stock, agriculture, and horticulture during "agriculture week." It is expected that the association at its second annual meeting will appropriately recognize the good offices of the parent association.

The work of this committee having been accomplished, we recommend that it be discontinued.

Respectfully submitted.

W. M. HAYS.
L. H. BAILEY.
C. F. CURTISS.
Committee.

The report was adopted.

COOPERATION BETWEEN THE STATIONS AND THE U. S. DEPARTMENT OF AGRICULTURE.

E. A. BRYAN, of Washington. In behalf of the committee on cooperative work between the experiment stations and the United States Department of Agriculture, I would say that all matters of concern in connection with cooperation have become of such importance that it seemed desirable and necessary that the executive committee of this association should take immediate cognizance of that work, and they have, during the past year, had that matter entirely in charge and have already made a report to this association in regard to the cooperative work, so that any further report on behalf of the committee seems to be entirely unnecessary.

MEETING PLACE OF NEXT CONVENTION.

E. Mead, of the U. S. Department of Agriculture,[a] presented a large number of cordial invitations from California to hold the next convention of the association in that State.

Cordial appreciation of the invitations and of the hospitality extended on the previous visit to the State was generally expressed and a resolution offered by

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[a] Representing the California Experiment Station.

J. K. Patterson was adopted, expressing the sense of the meeting that the invitations should be accepted if it seems feasible to do so.

The convention adjourned at 10 o'clock p. m., to meet November 16, 1905, at 9 o'clock a. m.

MORNING SESSION, THURSDAY, NOVEMBER 16, 1905.

The convention was called to order at 9 o'clock a. m. by the president.

FORESTRY IN LAND-GRANT INSTITUTIONS.

The chairman of the executive committee reported back to the association the series of preambles and resolutions, by S. B. Green, of Minnesota, already given in full on page 27, with the recommendation that they be adopted in the following form:

Whereas the forests of this country are fast disappearing and little or no attention is being paid to their renewal: and

Whereas the development of this country is seriously threatened by a shortage in timber supply: Therefore be it

Resolved by the Association of American Agricultural Colleges and Experiment Stations in convention assembled, That the national forestry policy of this country should include provision for education and experimentation in forestry by the agricultural colleges and experiment stations of the different States and Territories.

S. B. GREEN. Our forest resources seemed at one time to be inexhaustible. It seemed as though we had such a wealth of forest that we could never use it up. But we are fast getting to the point when it is a question where we shall get the valuable timbers and woods to use in our industries. The increase of stumpage value has been enormous in the past ten years. We have been working our timber resources just as we would a mine. We have not treated them as though they could reproduce themselves, and the land that has been cut over is practically nonproductive to-day. It is brush land, burned over every few years, and on which the new growth is of little value. There is a shortage of timber, and timber is the foundation of many of our industries.

There is an immense amount of mining riches in the United States that ought to be developed, but it is probable that there is hardly a mine made which does not have to be heavily timbered; and there are no heavier consumers of timber than our mines. And in many sections of the country to-day they have difficulty in finding timbers for properly timbering their mines.

I know of one mine in Minnesota that uses something like 80 miles of log timber in a year. We have an enormous amount of waste land that is unproductive, not only in Minnesota, where we have many millions of acres of that kind, but throughout the United States. There is not a State in this country that has not an enormous amount of land that is nonproductive and could be made productive, if properly cared for, in forests.

Without forests we are going to be handicapped in the development of this country. We have been working a primeval source of timber supply. Somebody may say that the forests of Oregon are inexhaustible, or those of the Pacific slope; but they are not. It should be remembered also that more timber has been destroyed by fire in this country than was ever cut by the lumbermen, and the cause of the fires lies in the lack of realization as to the amount of damage that is done by it. There is not a State which does not need forest instruction. There are some States where the people are very apathetic in regard to this matter.

The National Government is doing a grand work through its Forest Service in the spreading of correct ideas as to forestry throughout this country, and its management of the forest-reserve business has been such as to be very gratifying to the American people; and yet we need to have, in order to carry that work out to its fullness, a better, a higher intelligence among the people as to the possibilities of forestry—as to what it is reasonable to expect from forests. How can we spread that information, is the question. It seems to me that that could be best undertaken by the land-grant college.

It seems to me that these land-grant colleges are especially fitted for this work. Forestry is an agricultural subject, and the subjects which are generally taught in our agricultural colleges bear with directness upon forestry, and forestry could be added to these courses very easily. My idea is this, that we ought to look upon this matter of instruction in forestry in our agricultural colleges as a part of the national policy of spreading correct information in regard to forestry through this country. Some one may raise the argument that iron and concrete and cement are largely replacing wood in construction. That is true to a large extent, and yet, in spite of all that, the per capita consumption of wood has increased since the substitution of these other materials for wood has come into vogue.

Gifford Pinchot, of the Forest Service. Mr. Chairman and gentlemen, I am particularly glad to have a chance to say a word on this matter, because I feel very strongly, indeed, the desirability of the work that Professor Green has laid before you. I think we may fairly divide instruction in forestry into two perfectly separate and clear-cut parts, just exactly as we may divide instruction in almost any other professional subject in the same way. On the one hand is that instruction which is intended to make professionals who will practice law or medicine or forestry, or whatever it may be—giving their whole lives to it; and on the other side is the instruction upon which the general intelligence of the country is based, the instruction that a man needs who is going to give his life to something else; and as I understand Professor Green, it is the second of these two lines of instruction that he is advocating. I have gotten from Doctor True a statement of instruction in forestry in the land-grant colleges, and the figures show that 33 of the colleges are at present engaged in giving such instruction, two or three of them preparing men for professional work, the others teaching what may be called "agricultural forestry." Now, we are not going to find it possible at any time, I think, to bring trained men in contact with the farmer's wood lot unless in the future we should change our ideas of the Government entirely and begin State supervision of the lumber business. The handling of the wood lot by the farmer is going to control forestry over areas which are astonishingly large. For instance, there are now at least twice as many acres in wood lots in farms as there are in national reserves. And if a man who owns it can understand how to handle it, or, if he does not, can employ a professional forester to come and show him how, there is an enormous gain; and, on the other hand, if the men who pass through the land-grant colleges who are not going to make forestry a profession can have the same knowledge as a student in a business college has about law, which does not fit him to be a lawyer but is of the very greatest service to him in his work, then I think a very great service has been rendered. I see no reason whatever, if things go on as they are going now, why we should not have better intelligence among the masses of our people about forestry than any other country in the world. I think our people now understand what forestry means better than any other nation. Forestry is a live topic here, and it has never been more live and more prominent in the minds of the people than it is just now. All of that means to me that this is a most desirable thing to do, and I want to back it up just so far as I am able to. I would not want to back it up—and I want to make that perfectly clear, and I should be compelled to back the other view—if this meant that a lot of men, half educated in forestry, were going to be turned loose on the country as trained foresters. That would be the most serious setback that our forest work could have, and any influence that might be brought to bear against it would be a good thing to be brought to bear. That would put us in the same position that the medical profession would be put in if a lot of people could be turned out as regular doctors who had had only six months' or a year's training. The profession of forestry and the training for it is an entirely different thing from this most desirable spread of general information about forest topics.

Now, it is quite possible—and I should like to make the offer very heartily—if this matter goes through the Forest Service can be of use to the different land-grant colleges and to the experiment stations in giving advice when called upon, and, perhaps, in recommending men or furnishing publications, or in any other similar way. And I want to say that we should be only too glad if in any of these directions we can be of use to you if this matter goes through. I feel very strongly indeed about it, because we have been taking this up, and our attention has been called to it in the Forest Service in the last two or three years, that the most desirable thing that could happen to the Forest Service in this country would be to make the general rough outlines of it generally known, and, as Professor Green has very well said, the solution of this question is in the minds of the people.

C. A. Keffer, of Tennessee. It seems to me that the matter of forestry education in the land-grant colleges has about the same relation to technical forestry education as has the general course which a college gives to a special course in medicine. In many and, in fact, most of the colleges students who have taken the biological-science course are given credit for it when they come to take their special courses in medicine, and there is a gain to all the people wherever the preliminary course in forestry is offered to students at home before they shall undertake the technical courses of the larger profession, the technical courses that they must have in order to go into the business as foresters. There is a gain, then, from the student's point of view and there is economy from the student's point of view in offering in the land-grant colleges lines of work that shall lead and shall prepare for the more technical course that the forestry schools offer. I can see no advantage in multiplying technical forestry schools. The country has now a Forest Service. These courses would appeal to the students, and we should inevitably prepare men in advance of the demands of the country, and it seems to me that this would be a misfortune. Aside from that, relief would be given to those professors who are attempting to teach forestry in the land-grant colleges in addition to their regular work. In Tennessee, and I think generally in land-grant colleges, instruction is given by the horticulturist or the botanist, whose duties in his original line would seem to require all his time. There is, then, need of relief in this way in this direction, and there is no doubt that instruction offered by experts should be just as valuable in this line as in any other line of scientific research. I myself have found that there is hardly a more interesting subject for the student than forestry. It is a line of work that has two phases. There is the biological phase, which so many enjoy, and then there is that larger application of the trend of a great principle in general mechanics which is yet to be developed, and it seems to me, as one factor in the resources of the country, we have in forestry one of the subjects that ought to have a large place in the work of the land-grant institutions. If these land-grant institutions came closer into the lives of the people this would help us in developing the national resources. With forestry there is quite as much need of conservation as of development. We have reached a point where the business of lumbering is probably as thoroughly developed as any in the United States, but we have not reached a place where the business is taking care of the resources on which the business is based. It would seem that the source of this business is being dissipated. We all know that the business of lumbering is gone from the North. In Tennessee, indeed in all the Southern States, there is need of careful study of the hard woods of the country. In the Central South there is, as you all know, the greatest hard-wood forest of the country, and yet I suspect the forester is not as fully advised as he should be as to the best means of handling this important forest. From the point of view of the forester, and from the larger point of view of those interested in the conservation of the national resources, it seems to me that anything that can be done in the direction of instruction in forestry ought to be commended by this association.

The resolution as amended was adopted.

ELECTION OF GENERAL OFFICERS.

H. P. Armsby, of Pennsylvania, presented the name of M. H. Buckham, of Vermont, for president of the association. J. K. Patterson seconded the nomination. The secretary of the association was instructed to cast a unanimous vote for President Buckham. In like manner C. C. Thach, of Alabama, was nominated and elected first vice-president; E. H. Jenkins, of Connecticut, second vice-president; J. H. Worst, of North Dakota, third vice-president; B. I. Wheeler, of California, fourth vice-president; and L. Foster, of New Mexico, fifth vice-president; J. L. Hills, of Vermont, secretary-treasurer; and A. C. True, of the Office of Experiment Stations, bibliographer.

WORK OF THE OFFICE OF EXPERIMENT STATIONS IN AGRICULTURAL EDUCATION.

T. F. Hunt, of New York, introduced the following resolution:

Resolved, That this association recognizes the great value of the work of the Office of Experiment Stations in promoting the cause of agricultural education in the United States, and heartily indorses the action of the Secretary of Agriculture in encouraging and aiding the efforts of the Office in this direction.

The executive committee recommended immediate consideration, and the resolution was adopted.

VOTE OF THANKS TO REPRESENTATIVES ADAMS AND MONDELL.

J. L. Snyder, of Michigan, offered the following resolution:

Resolved, That a vote of thanks be extended to Representative Adams for his efforts in behalf of securing increased appropriations for the experiment stations of the United States.

The executive committee recommended immediate consideration, and the resolution was adopted.

J. K. PATTERSON. I think we ought to couple the name of Representative Mondell with that of Representative Adams in the vote of thanks and confidence that has just been given expression to in behalf of Mr. Adams. We are all interested in that measure, some of us more and some less, but we are also interested in the passage of a bill that will add to the existing endowments of agricultural and mechanical colleges in the special direction of schools of mines and mining and engineering. I believe there is a possibility of passing this or some kindred measure, and Representative Mondell has been committed to its advocacy hitherto, and it seems to me it would be a fitting tribute to what he has already done, and it would be an encouraging stimulus to further effort to couple his name with that of Mr. Adams in the resolution just passed. I therefore move that a similar vote of confidence and thanks be accorded to Representative Mondell, and that the secretary be directed to transmit the resolution to him.

The executive committee recommended immediate consideration, and the motion was unanimously agreed to.

ANNUAL DUES.

The secretary moved that the annual dues for each college and station be fixed at the usual sum, $15, for the ensuing year, and the motion was agreed to.

FEDERAL AID IN CONTROL AND EXTERMINATION OF THE GYPSY MOTH.

H. J. Wheeler, of Rhode Island, offered the following resolution:

Whereas the gypsy moth has already gained a foothold in three States in the Union; and

Whereas it has as yet no effective parasite enemies in the United States and is in consequence a menace to the agriculture and forestry of the entire country: Therefore be it

Resolved, That this association is of the opinion that the time has come when the Federal Government should lend its aid in the control and extermination of this pest.

The executive committee recommended immediate consideration, and the resolution was adopted.

MEMORIAL TO PRESIDENT H. H. GOODELL.

President W. E. Stone, of Indiana, delivered the following memorial address upon the life and services of President Henry Hill Goodell:

Since the organization of this association few of its gatherings have been without the conspicuous and efficient participation of one whose absence from the last annual meeting was so notable and the occasion of so much comment. At that time the thought would scarcely have occurred, even to his intimate friends, that the long and honorable service of President Goodell to the American agricultural colleges and experiment stations had been completed.

In the interval since that meeting his name has been written on the long roll of the dead, and the association meets to-day in special session to express its respect for his memory and appreciation of his work.

To some of my hearers no word of mine can convey a better knowledge of the worth and work of our late associate than they already possess from their personal acquaintance and collaboration with him. But there are many other members of this association who from the nature of things must have an imperfect knowledge of the services of President Goodell and his contemporaries in the early stages of its history.

A review of his life and work may therefore have a twofold result: It will enable us all to rightly value his high worth, and it should impress upon us the significance of the work of this association in the past, the importance of the policies that have been pursued, and the inestimable value of the services of those men who have been leaders in the inception and early work of the association.

During all of his active life President Goodell toiled unceasingly in that work of the establishment and advancement of agricultural education which has been the principal educational event in America in the last half century; yet, strange to say, he was not by birth, tradition, or training connected with agriculture in any way. Born of missionary parents in a foreign land, and educated in a typical New England college of liberal arts, one could scarcely have predicted for him such a career as he followed. But a coincidence of events brought him, youthful, ardent, and resolute, face to face with the beginnings of two historic epochs worthy of his entire devotion—the civil war and the establishment of the great Federal system of industrial and technological education. His character possessed traits which made it impossible for him not to engage in these great movements. It was not prevision, for his nature never asked hostages of the future; but it was a call of immediate duty, a sense of important work to be performed which led him first to the service of his country, and, after a brilliant career in the field, to enlistment in the first faculty of one of the first colleges to be established under the Morrill Act, where he labored continuously and conspicuously until his death.

Henry Hill Goodell, son of the Rev. William and Abigail Goodell, was born in Constantinople, Turkey, May 20, 1839. He prepared for college at Williston Seminary, Easthampton, Mass., and graduated from Amherst College in 1862. He was commissioned second lieutenant Company F, Twenty-fifth Connecticut Volunteers, August 16, 1862, first lieutenant, April 14, 1863, and was appointed aid-de-camp on the staff of Colonel Bissell, of the Nineteenth Army Corps, July 8. He participated in the engagements in Louisiana of Irish Bend and Vermillion Bayou, in the siege of Port Hudson, and in the Teche campaign, and was mustered out of the service August 26, 1863.

From 1864 to 1867 he was an instructor in Williston Seminary, and at the opening of the Massachusetts Agricultural College in 1867 was appointed professor of modern languages and English literature. In 1886 he was elected president of the college; in 1887 director of the experiment station, filling both these offices until his death. He was an original member and one of the founders of the Association of Agricultural Colleges and Experiment Stations, president of the association in 1891, member of the executive committee from 1888 to 1902, and chairman of the same from 1894 to 1902. In the spring of 1905 he went to Florida to recuperate from an acute illness, and, being homeward bound, died on shipboard in Boston Harbor, en route from Savannah to Boston, April 25, 1905.

I pass rapidly these milestones of his career to dwell upon certain traits and achievements which will give us a true picture of the man. During forty-one years he was a teacher, and thirty-eight of these years were given to one institution. But if we think of him as a plodding college professor, performing only his routine tasks during all of this time, we shall do him injustice. His character was a rare mixture of energy and enthusiasm, with patience and enduring persistence, of breadth of view and love of detail. He was capable of the utmost self-forgetfulness in rising to the demands of an emergency. He was also able to toil indefinitely at an obscure task which he believed worth doing. He possessed and retained an optimistic and enthusiastic courage characteristic of youth, but with him an inborn trait. He was not self-conceited or self-confident, but he was self-reliant, and when he faced any issue with cheerful and hopeful trust in the outcome, as he always did, it was simply an expression of this side of his character—of his faith in the ultimate triumph of right. Those who knew him well had no need to call upon their imaginations to picture him in the midst of a desperate hand-to-hand struggle in the assault on Port Hudson, acquitting himself with signal bravery, nor to see him, after this assault had twice failed, the first man to respond to a call for volunteers to lead a forlorn hope. He had all of the martial spirit and abandon to become the foremost figure at such a time, but without boastfulness or swagger, and he had also the greater courage to face the repulses and obstacles of life modestly, but unyieldingly.

More than twenty years ago he stood face to face with an insidious and fatal disease, the assaults of which might well have made the stoutest heart sink. But few of his friends knew of it. None ever heard him complain. By sheer determination he repulsed the attack and held the foe at bay for years. The last years of his life were a constant struggle with disease, but few would have guessed the fact, nor would he swerve from the conscientious performance of his duties on this account. Some men possess a courage which is inspired by excitement. Others have that quiet courage which is firm under the most depressing conditions. President Goodell's courage was a part of himself—dominant and ever present. In the hours of deepest trial he was not cast down. No danger was great enough nor any misfortune so threatening as to drive from his face a cheery smile or from his lips a kindly greeting.

But this energy and courage were mingled with a genial and sympathetic disposition and were tempered with wisdom. These qualities inspired love and confidence on the part of his associates. In the army his comrades voluntarily placed their pay in his hands and sent him on a long and dangerous journey to bring this large sum to a place of safety. Later he was trustee of the relief fund of his Grand Army post. His fellow-citizens trusted him also, and he was identified in a helpful way with all good movements and enterprises in the town of Amherst, where he lived.

The excellent public library there exists as a monument to his efforts, and it gives us insight into his industry and energy to know that for many years he gave his time to the details of the work, so that, it is said, more than 7,000 entries in the card catalogue are in his handwriting. In a like manner he was vestryman, delegate, and committeeman in his church and clerk of the same for twenty-five years. He was president of the Amherst Club, representative to the legislature, member of the Massachusetts Horticultural Society and of the Massachusetts Agricultural Society.

These were all matters incidental to his real life work, but his interest in and devotion to them were characteristic of the quiet, service-seeking side of his nature, which at times could also rise to heights of enthusiastic action.

To the Massachusetts Agricultural College he devoted his life, beginning when a young man of 28, from which time until his death, a period of thirty-eight years, he gave unsparingly all that he had in any service which could be of value to that institution. He was appointed to instruct in literature and modern languages, but, with a fine spirit of devotion, he did not think it beneath his dignity, as the necessities of the college demanded, to serve at different times as instructor in gymnastics and military tactics, as lecturer in entomology, as instructor in anatomy and physiology, and as instructor in rhetoric and elocution. He was also for a time secretary of the faculty, for fourteen years librarian, for some months acting president, and, finally, for nineteen years president. He rendered this variety of service not because of any restlessness or special versatility, but strictly from a sense of duty to the college, which in its early days was often compelled to utilize all of its resources in order to fulfill its obligations to students. As one contemplates this record of service he is struck by the devotion, the capacity for application exhibited by President Goodell, and the amount of work which he actually turned off. For instance, he was a passionate lover of books, and early took upon himself to care for the college library. For many years, in addition to his other duties, he was librarian in fact as well as in name, selecting and purchasing books, keeping records, preparing the card catalogue, arranging exchanges—all with marvelous efficiency—and thus created by his own personal efforts one of the most complete and well-selected agricultural libraries in the country.

The college was for many years one of the pioneers in the field, located in a community in which agriculture was a minor industry, and surrounded by an educational atmosphere which was unsympathetic, if not hostile. The conditions were discouraging and incompatible to a young man of Goodell's training and temperament, but here again his quality of courage, based on confidence in the right of things, kept him faithfully at his post, and he lived to see the day when, largely through his own efforts, the college had established itself in the esteem of the community, overcome prejudices, and secured a high educational standing. Through all of this evolution he adhered persistently to high standards of education, such as seemed to him befitting the institution and the intellectual conditions of the State.

When he became president of the institution it stood sadly in need both of students and resources. The problems before him were difficult, involving, first of all, the establishment of public confidence in the college. His labors in this direction were forceful and effective, and he soon succeeded in securing needed recognition from the State. During his presidency the real estate of the college increased in value one-third; its equipment, fourfold, and its income, threefold.

His relations with students were firm but kindly; severe in discipline, but only as a last resort, and withal with such sympathy and kindliness of heart that few others of the long-time members of the faculty were so well beloved as he. He kept up a large correspondence with alumni and old students, resulting in an exceptionally accurate record of all who had ever attended the institution. He remembered and could call by name most of those who had come under his care. With this record of quiet, unselfish, and effective devotion to the institution and its students, it is no wonder that his name is affectionately cherished and honored at the Massachusetts College.

In the work of this association, and in the establishment of the foundations of the land-grant colleges and experiment stations, President Goodell had an important and almost unique part. A full comprehension of this can only be had by those who shared with him these labors. With the passage of the Hatch Act it became apparent that an organization of the executive officers of these institutions was a necessity. The attention of Congress could only be secured by he presentation of matters of national scope in concrete and unified form. The plan of education and research mapped out for the land-grant colleges was too broad, varied and comprehensive, and too vital to permit of its development without organized direction. It was necessary on more than one occasion to urge upon Departments of the Government a consideration of conditions which led to fair and beneficial rulings with regard to these institutions. The questions of jurisdiction and of the relations between the separate institutions and governmental Departments were, and have ever been, of greatest importance. The heads of these colleges were pushing out into new and unexplored regions, and felt the need of mutual aid and advice. All of these considerations emphasized to Goodell and his colleagues the necessity of an association for mutual aid and protection, as well as for the general advancement of the interests to which these institutions were devoted. In the organization of this association he was a moving spirit, and in its subsequent work always an active participant. He was a member of the executive committee from 1888 to 1902, and during the last eight years of this time was chairman of the same. In this capacity he labored untiringly, not only in the broader duties of the position, but in multitudinous details which contributed to the success of the organization. One can recall distinctly his methods of preparing and presenting the business of the association in a complete and finished manner, which expedited the routine of its work, even at the cost of apparent officiousness on his part. His rare tact and insight into human nature; his broad outlook upon the field of agricultural education; his wide knowledge of public men, and thorough familiarity with the history of the land-grant college movement fitted him for the place of leader in the work of the executive committee and enabled him to render inestimable service. The attention of Congress and of governmental Departments has been favorably molded by the wisdom and firmness of this committee. The threatening danger to the Federal appropriation to the colleges and experiment stations through the gradual diversion of the proceeds of the sale of public lands was foreseen and averted through his efforts and leadership in securing protective legislation in 1900. His conservative and wise but energetic action averted many dangers and laid foundations which will sustain our institutions for a long time to come. That we have passed through this period of development so safely is due to a strong organization and able leaders, among whom Henry Hill Goodell stands conspicuous. To few, if any, of these do the agricultural colleges and experiment stations owe a greater debt than to him.

Such an example should long survive the life that gave it and long continue to inspire and guide the members of this association. In meeting new conditions and emergencies, we shall do well not to abandon those established principles which characterize our institutions; we should seek conservative rather than too liberal interpretations of the statutes, and we should be willing to intrust larger responsibilities and greater freedom of action to tried and wise leaders.

Thus far I have spoken of President Goodell's work and achievements, with little reference to his character. But no tribute to his memory may consistently omit the highest appreciation of his personal qualities. He did much, he served well, but he will be longest and best remembered for those traits which endeared him to all who knew him.

His was no common spirit. I should like to know more of his ancestry, to trace those fine and subtle threads which wove the texture of his character. All the substantial qualities of a man of honor were his—frankness, honesty, sincerity, courage, fidelity, and much more. He possessed a true nobility of soul, an instinctive gentility, a spirit of chivalry which eludes analysis but which made itself unceasingly felt. The very fitness and high quality of his traits caused him to be sometimes misunderstood. As a matter of fact, no man was more democratic; and although by some deemed aristocratic and distant, no man was more genuinely sympathetic. In truth, he had in him nothing vulgar or commonplace; his being repelled familiarity; his fibers were attuned to the sweet and true notes of life, but the coarse and gross affairs of men awoke in him no answering chord.

I have known no man who seemed to embody so much of the chivalrous spirit; that spirit which takes no advantage of an opponent, which yields to others, which sacrifices all for a friend, which is embodied in the untranslatable noblesse oblige. His generosity and self-restraint gave always to others the opportunity and took to himself the obscure and painstaking task.

He lived a full and rich life of service in a great cause, and left a record of permanent achievements, but the finest and best of his life was known only to his intimate friends and to his students, to whom he revealed a true nobility of conduct and a splendid character that was an inspiration to all who came within its influence.

The executive committee was instructed to provide, if practicble, for the printing of the address in separate form after its appearance in the proceedings.

M. H. Buckham, of Vermont, offered the following resolution:

Resolved, That the association desires to put on permanent record its high appreciation of the personal character and eminent public service of President H. H. Goodell, of the Massachusetts Agricultural College, and especially to bear testimony to his wise, brave, and faithful labors in commending to public comprehension and confidence the cause of real and practical education in agriculture in its early days of experiment and conflict. The association also recalls with grateful appreciation President Goodell's laborious and efficient services during his eight years' tenure of the office of chairman of the executive committee of this association.

The resolution was adopted by a standing vote of the association.

Report of Committee on Indexing Agricultural Literature.

A. C. True, of Washington, D. C., read a report from the standing committee on this subject, as follows:

Since the last meeting of the association printed catalogue cards have been issued for three standard foreign periodicals devoted to agriculture, "Annales de la Science Agronomique," "Landwirthschaftliche Jahrbücher," and "Die Landwirthschaftlichen Versuchsstationen." As is well known, these cards are prepared by the library of the Department of Agriculture and printed and sold by the Library of Congress. This cooperative arrangement for furnishing printed cards at a nominal price has been satisfactorily accomplished and now awaits sufficient encouragement from subscribers to warrant its continuation. There are at present only ten subscribers for complete sets and eleven subscribers for partial sets of the cards. It is estimated that the cards for complete and partial sets together are about equal to fifteen complete sets. This represents a small number of subscribers compared with the number of scientists throughout the country engaged in agricultural research work, and for whose benefit the cards are largely prepared. The question now presents itself after one year's trial, as to whether the demand is sufficient to continue this special indexing and to add other periodicals to the number to be indexed. To make it worth while to prepare, print, and distribute such cards, it is necessary to have thirty-five additional subscribers at least. If the agricultural college or experiment station of each State would subscribe for one set of the cards this would insure the continuance of this work and make it possible to provide individuals with whole or partial sets at reasonable cost. It is estimated that an annual subscription of $25 from each college or station would be required.

The above-mentioned periodicals have been indexed through 1904, and the copy for numbers published in 1905 awaits the decision of those most interested in the work as to whether it shall proceed. The cost to keep the indexing of these periodicals up to date will be small, but it is hoped that the subscribers will desire cards for one additional periodical each year until the indexing covers the representative agricultural periodicals.

It is a question whether the work thus inaugurated will in any case need the further attention of a standing committee of this association. It seems probable that the interests of the colleges and stations in this matter can be fully met through the library of the Department of Agriculture and the Office of Experiment Stations. The progress of the indexing will naturally be reported each year by the bibliographer of the association. Your committee therefore suggests that it be relieved from further service.

A. C. True, *Chairman.*

H. P. Armsby, of Pennsylvania. I move that the report be accepted, and in making that motion I want to say just a word. Our station is one of the few which have purchased sets of these cards. I have not followed up the matter closely, but I must confess that I am very much astonished at the very small number of institutions which are reported by Doctor True as having taken advantage of this opportunity. I can not see how any station can afford to miss this opportunity. I do not believe we can afford in our station work to ignore the vast masses of material and experimental data which have been accumulated in the last fifty or sixty years in foreign countries, and especially in Germany. I do not see how we can make proper use of our funds while ignoring that and saying that we have nothing to do with work abroad. Of course the failure to purchase one of these sets hardly implies that; yet it almost suggests it. It seems to me it is an important matter, and with an index prepared by the library of the Department in this way and available at a cost which is insignificant, I can not see how any experiment station in this country can afford to be without it.

The report was accepted.

REPORT OF COMMITTEE ON RURAL ENGINEERING.

A report from this committee was read by W. E. Stone, of Indiana, as follows:

Your committee would report that during the past year there has been a perceptible advance in the public recognition of the need and value of specially trained agricultural engineers and an encouraging, if slight, progress in arrangements for giving this instruction in rural engineering in the colleges of this association.

The reasons for giving greater attention to this subject have been enumerated in the two previous reports of this committee and need not be repeated here. They are found in the changing conditions of farm life and farm labor in this country, and, being based on a fundamental need, they will endure and become more urgent and apparent until adequate provision is made.

Among the evidences of progress during the past season is the strengthening of the equipment in Iowa, the extension of the instruction in Cornell, and the provision for a complete course in rural engineering contemplated in Wisconsin. The strengthening of the work along experimental lines in a number of institutions is also clearly apparent, all showing an awakening attention to this subject. But along with this there are some unsatisfactory features. Chief of these seems to be the lack of a clear perception of the scope of courses in rural engineering, of what is required to equip young men to do the work needed to be done, of a lack of confidence in the value of courses of this character, which must be established before the best results can be obtained. In other words, the rural engineer is not yet a definite figure in this country, and our colleges are still floundering in their efforts to provide for his training.

In order to obtain a more definite understanding of what is regarded as rural engineering in the colleges represented in this association and the kind of training given under this classification, one of your committee mailed an inquiry as to the subjects taught, by what professor or instructor, the equipment for the work, and the plans for future development. The letter was unfortunately mailed too late for more than half of the colleges addressed to prepare and return replies. Those received, however, show that the greatest progress being made is in providing equipment for teaching and experimental work in farm mechanics, Iowa taking the lead in this, being followed closely by Cornell and Illinois. There are a number of western institutions giving complete courses in irrigation, Colorado and California giving the most thorough training, the work in both these institutions giving complete courses in irrigation engineering.

The replies, however, showed a wide diversity of opinion as to what is included in rural engineering. Some seem to indicate that elementary courses in carpentry and blacksmithing are entitled to this designation. This your committee regards as erroneous. They are related to the training, but they are no more entitled to be classified as a course in rural engineering than a few exercises in budding and grafting are to be considered a course in horticulture, or a few exercises in stock judging are to be classified as veterinary science. The only colleges which are entitled to claim that they are giving courses in rural engineering are those which fall within the definition given in Circular 45, the Fifth Report of the Committee on Methods of Teaching Agriculture, or those which are giving complete and independent courses of instruction in certain well-defined branches of rural engineering, like irrigation engineering or drainage engineering.

Another and more serious defect in the present instruction given by our colleges is the evident fact that the arrangements for giving this instruction are in too many cases mere makeshifts. In some of the colleges these subjects are taught by the department of civil engineering, in others by the department of mechanical engineering, and in others the work is a part of the department of agronomy. In one college it is taught by the department of mathematics, in another irrigation is taught by the department of horticulure, in another farm machinery is taught by the department of animal husbandry. All will agree that animal husbandry taught by the department of horticulture would be a somewhat anomalous arrangement. It might be justified on the ground that pigs will eat the fruit which falls from the trees, and hence there is a relation between the two subjects, but the teaching of animal husbandry by the professor of horticulture is no more ineffective than the attempt to develop an effective course in rural engineering by making it a part of horticulture or making it a part of animal husbandry.

Furthermore, there is a lack of recognition for those in charge. No one can fail to be impressed by the fact that, so far as the makers of courses of instruction are concerned, this work does not stand on an equality with the older established branches. Except for the colleges giving a course in irrigation engineering, no institution gives the man in charge of this work equal rank with the man in charge of other departments—such as agronomy, animal husbandry, horticulture, dairying, etc. Omitting those colleges teaching irrigation engineering, in only one college—Wisconsin—are courses in rural engineering recognized as a distinct department and accorded rank equal to other departments. In this respect the colleges of this country present a striking contrast to the recognition given this subject in the leading agricultural colleges of Europe. In Sweden, Denmark, Belgium, France, Netherlands, and Germany rural engineering is an independent department, with thorough courses of instruction and facilities for experimental work far in advance of anything yet contemplated in this country.

Your committee insists that the conception of this work given in the report of the committee on methods of teaching agriculture was a correct one and that the true value of this training, both to the student and to the development of the agricultural resources of this country, will not be achieved until courses in rural engineering are made as definite and independent as courses in animal husbandry, agronomy, and horticulture are now.

It is not believed that every institution should establish courses in rural engineering. Only those which have the equipment, or where the conditions of agriculture give opportunities for the following of this training, should undertake this. In States like California, where the investment in pumps for raising water in irrigation runs into millions of dollars, where the high price and scarcity of farm labor makes the use of costly and complex machinery imperative, and where irrigation and drainage are a prerequisite to the use of the greater part of the agricultural land, complete courses in this subject should be given, because a knowledge of them lies at the very foundation of successful agriculture, and young men equipped for this work have exceptional opportunities. Other institutions like Purdue, Illinois, Cornell, and many others which need not be enumerated, will, it is believed, find it in the line of progress to institute these courses.

Another fact brought out by the replies to these inquiries was that all that is needed in many institutions to provide for complete courses of instruction is a better correlation between existing departments, in order that each may give effectively its part of the training. It is believed that the establishment of courses in rural engineering will be an evolutionary process which will bring about a more complete fulfillment of the purpose of the Morrill Act. These colleges were established for the benefit of agriculture and the mechanic arts. The mechanic arts part has been developed into engineering colleges very similar in character to the best technical institutions of the country, but the agricultural courses and the mechanic arts courses are entirely separate from each other. Your committee believes that in the establishment of courses in rural engineering they can be made to greatly strengthen and help each other.

One thing which is doubtless in part responsible for this is the lack of textbooks, and these will not be provided until there has been a greater body of information brought together and systematized than is in our possession to-day. This means that there is need at present for experimental work. This is being recognized and provided for both by a number of colleges and by the Office of Experiment Stations of the Department of Agriculture. The work of the Office of Experiment Stations in tests of different types of pumping machinery and the conditions which affect its efficiency in the field will be of great service to the professors of mechanical engineering, because it will enable them to show the application of mechanical principles to the profit and loss of farm work.

Similar results are destined to follow the investigations of farm machinery now being inaugurated by a number of the agricultural experiment stations and by the Irrigation and Drainage Investigations of the Office of Experiment Stations in the Department of Agriculture. We must in the near future begin to consider as never before the economy of different types of farm machinery as compared to hand labor, and the relative economy of machines operated by horsepower and machines operated by gasoline, steam, or electricity. In determining this economy in a practical way, the mechanical knowledge and skill of the farmer himself are an important factor. Tests of pumping machinery show variations in efficiency from 5 per cent to 80 per cent. In other words, the fuel used in some engines gave sixteen times the service it did in others. A little of this was due to superiority in types of machinery. The greater part was in knowing how to keep it in proper working condition. In other words, there is the same opportunity for improvements in American farm practice in the line of machinery that has already been achieved in the breeding and management of plants and animals. This fact is being appreciated more clearly by the manufacturers of farm implements than by the farmers themselves. Every institution which has inaugurated investigations of farm machinery has been astonished at the liberality which the manufacturers of farm implements have shown in doing this work. The spirit of these manufacturers was strikingly illustrated at their recent annual convention at Niagara Falls, where the following resolutions were passed:

"*Resolved*, That we indorse and commend the agricultural engineering investigations of the United States Department of Agriculture, and believe their extension will benefit both the users and makers of farm machinery.

"*Resolved*, That a committee of three be appointed by the president to confer and advise with the proper governmental authorities about the conduct and extension of these investigations. We also recommend as features of these inevstigations the establishment of a laboratory and museum for the testing and illustration of principles of farm mechanics.

"*Resolved*, That we indorse and commend the teaching of farm mechanics and agricultural engineering in the various agricultural and other colleges, and that we pledge to all of this work our cooperation and support."

In conclusion, your committee expresses its belief that there is at the present time an urgent need in this country for a few institutions to establish independent courses in rural engineering, to rank with those now existing in some of the leading agricultural colleges of Europe, and that in order to do this these courses should be independent departments of the college, with adequate facilities for teaching and experimentation; that the men engaged in teaching such subjects should be classed as rural engineers and should have the same rank as professors in other departments; and that a vote of thanks be extended to the National Association of Implement and Vehicle Manufacturers for the aid and support they have already given to experimental work in farm mechanics; and that the efforts of the Secretary of Agriculture and Director True, of the Office of Experiment Stations, to enlarge these investigations, be commended.

W. E. Stone, *Chairman*.

The report was accepted and the secretary was instructed to extend the thanks of the association to the association mentioned in the report, in accordance with the recommendations of the report.

Nutrition Investigations.

A. C. True. As the work of the agricultural experiment stations developed, it seemed clear that it would be unwise for either the experiment stations or the Department of Agriculture to stop their studies of food products when they had studied questions relating to their production and use for farm animals; and so, under authority of law passed by Congress, investigations relating to the nutrition of man were authorized in the Department of Agriculture and assigned to the Office of Experiment Stations. At the same time, the agricultural experiment stations were authorized to carry on investigations on this subject. That was about twelve years ago. Since that time, especially under the direct leadership of Professor Atwater, though as a constituent part of the work of the Office of Experiment Stations, a very large amount of data has been accumulated along these lines. Much of this has been put in the form of publications, which have been widely distributed. These investigations have been carried on under a cooperative system by means of which a considerable number of the institutions represented in this association in different parts of the country have joined in the work.

Along with that there has been a very considerable development of departments of domestic science or home economics in the land-grant colleges, and this work on human nutrition has been used quite largely in the development of those departments. We have now reached a time in the progress of the nutrition investigations when it seems that it will be possible to make the results of this work much more largely useful to such departments of the colleges, and we are extremely desirous to do that. As you doubtless know, if you have followed at all the course of the departments of home economics in the different institutions, they have had the same problem that has confronted the other departments—namely, the development of sound pedagogic methods. Starting with work that was of an extremely simple and practical nature, they have been more and more desirous of putting the instruction on a sound college basis—that is, to give it a scientific basis and standing, so that the departments of home economics in colleges might take the leadership in that work as regards the lower schools. It must be borne in mind that at present there are thousands of schools in which subjects relating to domestic science and home economics are already taught. Thus far the work done along that line by the Office of Experiment Stations has related quite narrowly to human nutrition; but there are some other lines in which the Department of Agriculture has done some work, and as far as possible we desire to make such work also available and useful to home economics departments.

There is also a growing demand for a kind of work which will demonstrate more fully to the people at large the usefulness of such investigations and the practical advantages which may grow out of the application of science in various lines to the affairs of the household. So that, as it seems to those of us who have been close to this work, the time is ripe for a considerable development in this line of endeavor, and, in order that the Department may more efficiently do its part of such work, the Secretary has this year estimated for a somewhat larger appropriation. The increase, if obtained, is to be mainly spent in getting into closer relations with the teachers of home economics in the land-grant colleges and other institutions having similar departments, and also in demonstrating to a wider constituency the usefulness of such work. I am sure this is a matter in which the association is interested, and that it will cooperate in all good ways toward the building up of this enterprise, both by the Department of Agriculture and among the several institutions.

MISCELLANEOUS RESOLUTIONS.

On motion of H. C. White, of Georgia, the association expressed to President Stubbs its regret for his absence and its sympathy with him for the cause (death in his family).

On motion of E. A. Bryan, of Washington, the thanks of the association were unanimously voted the president of the association for the admirable way in which that office had been conducted during his incumbency.

The members of the convention, by special appointment, were received by the President of the United States. They were also extended the privileges of the Cosmos and University clubs during their stay in the city.

STANDING COMMITTEES.

The president announced the following standing committees:

Committee on instruction in agriculture: Three years—A. C. True, Washington, D. C., and T. F. Hunt, New York; two years—H. T. French, Idaho, and H. C. White, Georgia; one year—J. F. Duggar, Alabama, and W. E. Stone, Indiana.

Committee on graduate study: Three years—L. H. Bailey, New York, and H. P. Armsby, Pennsylvania; two years—M. H. Buckham, Vermont, and R. H. Jesse, Missouri; one year—W. O. Thompson, Ohio, and Brown Ayres, Tennessee.

Committee on extension work: Three years—K. L. Butterfield, Rhode Island, and C. R. Van Hise, Wisconsin; two years—B. W. Kilgore, North Carolina, and C. F. Curtiss, Iowa; one year—A. M. Soule, Virginia, and W. M. Hays, Washington, D. C.

Experiment station organization and policy: Three years—E. Davenport, Illinois, and C. D. Woods, Maine; two years—W. A. Henry, Wisconsin, and H. J. Waters, Missouri; one year—M. A. Scovell, Kentucky, and C. E. Thorne, Ohio.

Thereupon the convention adjourned sine die.

MINUTES OF THE SECTIONS.

SECTION ON COLLEGE WORK AND ADMINISTRATION.

Afternoon Session, Tuesday, November 14, 1905.

The section was called to order at 3 p. m. by the chairman, R. W. Stimson, of Connecticut.

Culture Studies in Land-Grant Colleges.

The first subject taken up for consideration was "To what extent should the baccalaureate degree courses of the land-grant colleges be severely scientific and technical—that is, inclusive or exclusive of so-called 'general-culture studies?' "

A. B. Storms, of Iowa, presented the following paper:

The Field and Functions of the Land-Grant Colleges.

Curriculum.—The avowed purposes of the land-grant colleges, according to the Morrill Act, being "to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life," to what extent should their baccalaureate degree courses be severely scientific and technical—that is, exclusive of so-called "general-culture studies?"

GENERAL EDUCATION AND TECHNICAL EFFICIENCY—"A MINIMUM GENERAL-CULTURE REQUIREMENT."

There are two important general considerations in determining what should be the scope and character of the courses of study in land-grant colleges—(1) the intent of the original land-grant act and (2) the evolution of the intent or idea in land-grant colleges. Seldom or never do the originators of any far-reaching and benificent idea conceive its execution in finished detail. Rather, they open a fountain of inspirational impulse. They initiate principles and outline the main working features of a plan. Broad-minded and benevolent statesmen, in devising plans for the future good of the race or of their country, are the last to wish to give stereotyped and rigid form to the details of their plans, knowing well that the vitality of a great purpose and fruitful idea requires a free atmosphere for its normal evolution.

Yet it is also true that a definite direction and limitation must be prescribed for the working out of an educational idea. Those have planned in highest wisdom who have either prescribed these limitations and given this definition only as governed by the main initial purpose, or have left the definition and limitation to be worked out in harmony with that central idea or purpose. No educational system can be successfully worked out that lacks consistency and coherence and organic unity within itself.

We should, therefore, ask as to the main features of the educational idea that found expression in the land-grant act. This, of course, is determined not only by the wording of the act itself, but by the discussions in Congress which led to the enactment. I think we may say, without attempting to resummarize the arguments, that the working of the act itself is a most happy expression of the central idea and purpose of the leading spirits who secured the land-grant enactment. That purpose is defined as being to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life. It was not the intention of the original movers of this act or of the Congress passing it that these colleges should be narrowly and severely and exclusively technical in their baccalaureate degree courses. A very interesting and instructive discussion of this very question arose in the State legislature of Iowa in 1884. The State of Iowa had founded in 1858 an agricultural college and model farm and had prescribed and limited its courses of study as follows: Geology, mineralogy, meteorology, entomology, zoology, animal and vegetable anatomy, veterinary surgery, and bookkeeping, and permitted no other studies except such as are directly in touch with agriculture. Desiring to take advantage of the national land grant, the legislature accepted the trust fund thus created and devoted it to the maintenance and enlargement of the agricultural college thus established by the previous act of the legislature. After a great deal of agitation and unrest the legislature in 1884 repealed the former act prescribing the courses of study, and enacted a new law providing that there should be adopted and taught at the Iowa State Agricultural College a broad, liberal, and practical course of study in which the leading branches of learning should relate to agriculture and the mechanic arts, but which should also include such other branches of learning as would most liberally and practically educate the agricultural and industrial classes in the several pursuits and professions in life, including military tactics. It will thus be seen that this bill proposed to change the law so as to provide a general and liberal course of study, in which agriculture and the mechanic arts should have a leading place, and to repeal the exclusive course that was provided by the statute. Senator P. M. Sutton, of Marshall, in an extended and extremely interesting argument before the senate, contended convincingly that to hold the land-grant funds to the narrow limitations of the previous law was a perversion of the trust funds by diverting them to a purpose quite different from the indication of Congress in passing the land-grant act.

The wisdom of this liberal purpose of Congress in the original act is worthy of all praise when we consider the character of the constituency of these colleges. The young men and women who go up to college in these institutions are very seldom prepared for or desirous of receiving a severely technical course. For the most part, the land-grant college is the only college and the only opportunity for higher education that these young people will find. These colleges are quite different from institutes of technology opened in the heart of great cities and in the midst of extensive manufacturing enterprises. Such technical institutes have for their sole purpose the technical education of specialists. It is not yet true, and probably never will be true, of the land-grant colleges that they are to be in the severe and narrow sense technical institutions.

There is a striking harmony between the utterances of the leading, aggressive educators of the present and the utterances of the men who urged forward the land-grant enactment. For instance, President Dabney, of the University of Cleveland, in his inaugural address makes the following statement:

"Since higher education produces more efficient men and thus increases the productivity, the wealth, and the power of the nation, it is the duty of the State or city to provide not only free schools, but colleges and universities for the higher training of its citizens."

And Doctor Barrows, general superintendent of education in the Philippines, in a recent address, says the ideals of the Philippine educational work include "a large, general purpose to raise the spiritual character, the industrial efficiency, and the political capacity of the entire people."

The land-grant law is a significant and notable expression of the ideal of modern democracy in the sphere of education. The old aristocratic notion of a scholarly class, whose hands should be unsoiled by labor and whose refined minds should be untainted by industrialism, has given way to the democratic ideal of equality. This does not mean that all men are alike capable of higher education and efficiency, but it does mean that the line of division between classes of men shall not be artificial and arbitrary, but natural and spiritual. The educational ideal of democracy is that the privileges of education and of higher education shall be open to all who have the initial ambition, the perseverance, and the talents to improve such opportunities.

These colleges owe their birth to the deep and generous enthusiasm of statesmen who felt the validity of the democratic ideal of equality. It is the glory of our western civilization that it has increased initiative and has multiplied the individual efficiency of the average man. And the ideals of the founders of these colleges being the legitimate expression in the sphere of education of that which is most characteristic of western civilization, must be cherished in an atmosphere of like generous enthusiasm and breadth of view.

We must consider the character of our students. They are largely from the thrifty industrial classes. They have virile manhood and womanhood. The elemental qualities that make for strength are there. Our first consideration must be such educational training and equipment as shall be calculated to raise "the spiritual character and industrial efficiency and the political capacity of the entire people." In the practical working out of our democratic system of education, we get, on the whole, the best material that was ever gathered within college walls. The initial implications as to character and personal force in the very fact of young men and young women seeking college training are extremely significant. The decision to enter college at all is a momentous one. It has large implications concerning the tone of life's ambitions and aspirations. It usually signifies a hunger for knowledge; an eagerness to get at books and to get into lecture halls and laboratories and to find the sources of information. An earnest and deliberate decision to enter college and to complete a full college course is usually itself an index of qualities of character, of intellect, and of will power that augur substantial achievement in life's work.

But we must also bear in mind that we live in a quite different age from that of the founders of these colleges. Their purpose and the scope of their work obviously were somewhat vague and indefinite at first. They were seeking a definition for themselves, a reason for their existence. Meantime there has been a most remarkable development in the fields of applied science—of science as related to the industries. The old single course in agriculture was quite a primitive and simple affair compared with the modern courses offered in the most advanced colleges of to-day. Instead of a general course called an agricultural course, offered in the Iowa State College of years ago, which contained a little general agriculture, with one professor giving such instruction as was given in the whole field of agriculture, we now have in agronomy proper nineteen distinct courses of study; in dairying, thirty; animal husbandry, twelve; horticulture, seventeen; agricultural chemistry, twelve; botany, with special reference to agriculture, nineteen; agricultural economics, one; rural law, one; or one hundred and eleven courses of study aside from the courses offered in the general sciences, in history, languages, mathematics, civics, etc. A like evolution, though not quite so radical or marked, has occurred in the schools of engineering. These courses, however, had a somewhat clearer and stronger development earlier, and the transition is not so marked. It is quite evident, however, in both the field of engineering and of agriculture, that the development has been so great and the demand has so increased for distinctively technical studies that these colleges might quite readily become purely and severely technical in all their baccalaureate courses.

When so many things are crowding for recognition in the curriculum and it comes to an issue between distinctively technical study and a general culture study, it is hard for the more general study to hold its own. The continual remodeling of the courses, the addition of new studies, would seem to threaten the exclusion at last of all the general culture studies. The question is a very pertinent one for us at this juncture, whether such a result is desirable, and if it be not desirable there should be some principle adopted by which the general culture studies shall have some minimum room given them in all courses offered for baccalaureate degree. In my judgment there should be such a minimum requirement of general culture studies in the first two years of the baccalaureate courses and some opportunity for electives in the last two years, and I say this knowing how difficult it is to make such provision, for instance, in a course of civil or mechanical engineering. These courses are already heavy. We can not add more studies to the requirements. I believe that the tendency has been overstrong to attempt the minute specialization in technical lines in our engineering courses particularly. It is a question to be seriously considered whether we should not react from this tendency and cease to expect to equip men for every distinctive technical field, and rather put the emphasis upon the fundamental principles of engineering, for example, or of civil engineering, if you please, and leave the student to develop those principles in the special field in which he may find himself after graduation. I was profoundly impressed by the statement made by Mr. John R. Freeman, vice-president of the American Society of Mechanical Engineers, on the occasion of the inauguration of Charles Sumner Howe, of the Case School of Applied Sciences, Cleveland, Ohio, in May, 1904. He summed up a very clear and forceful argument for a broad and thorough culture in technical schools in the following sentences:

"Recognize the fact that these four years' time with their attendant expenses are too valuable to be devoted to the attainment of mere manual dexterity. This can be more cheaply learned in the field or workshop than in the school. Do not shrink from turning out graduates who will be strong on theory while perhaps weak on practice. They can get their practice outside after graduation, and perhaps under the quickening influence of some short-lived ridicule by the routine workman, but the sound foundation of mathematics, the facility in handling and transforming difficult equations, the mental grasp of difficult considerations so as to state them in the language of mathematics and quantity, must be acquired in the technical school or the chances are that they will never be acquired."

Manifestly room should be found in every course that claims to be broadly educational for some comprehensive study of history that a man may be somewhat intelligent as to the forces and evolution of the political, social, and industrial institutions which he enjoys. Manifestly, too, he should study some other language than his own that he may have some facility in the use of a language as a means of expression. Manifestly, too, he should be a student of the English language throughout his entire course. He should be drilled constantly in the expression of his thought upon the subjects in which he is most interested. Of course the fundamental sciences—chemistry, physics, and mathematics—must have their place. They are fundamental not only in giving knowledge of principles, but as instruments of discipline. Along with these must be placed botany and zoology, the one or the other receiving emphasis according to the main course of study that may be taken. And along with the study of English must go the study of literature to a sufficient extent to give young men and young women somewhat independent standards of test. Civics and economics also may not be omitted. I would not go so far as President Howe has in his inaugural address, maintaining that philosophy and ethics and the history of art must also be included even in a technical course, but I would say with him, concerning the subjects that I have included, that a student can learn something of all these subjects during his college course and yet have a great deal of time left to follow his own individual tastes.

We must, indeed, prepare men thoroughly and not be content with superficial work in our technical courses. But the time has not come, and I believe it never will come, when the land-grant college should be severely and exclusively technical in its courses.

The question as to the amount of time to be given to general culture studies will be modified considerably by the nature of the entrance requirements. We in Iowa, for example, are now requiring for admission to the freshman year of engineering courses, besides English and elemental rhetoric, a semester of English literature, five hours a week; two years of French or of German; plain and solid geometry; history, and civics; or, in general terms, graduation from an accredited high school or its equivalent. Indeed, in mathematics few of the Iowa high schools are as yet including solid geometry. Many students will need to enter conditioned in solid geometry in the freshman year. In the civil engineering course, German or French five hours, both semesters; advanced rhetoric, five hours, one semester; composition, one hour, second semester; English history, one hour, first semester; formation of the Union, one hour, second semester; mathematics, five hours throughout the year; elementary engineering studies, three hours, first semester, and two hours, second semester, with possible election of two hours each semester in addition. The sophomore year, in addition to mathematics five hours throughout the two semesters, we have physics and chemistry and English, four hours of surveying, and one of drawing. In the junior and senior years the student's time is given almost exclusively to his technical engineering studies, with electives in history and English of two and of one hour. We would not claim that this arrangement of studies is entirely satisfactory, but it is the best that we have thus far been able to arrange. If the entrance requirements are low, relatively more time must be given to general studies within the college course proper. It should be recognized that a thorough high-school course is not in itself a mean education, nor should it be overlooked that technical studies have also a high cultural value.

There is a strong and significant tendency to bring educational interests near to the real interests of life. The cultural value of the sciences and of the applied sciences is being recognized as never before. Aside from learning thereby to do the things that need to be done in life, when properly pursued and with the requisite thoroughness and devotion, the sciences and the applied sciences furnish a discipline in education not inferior to that of the classics. Even the courses that seem mercilessly exclusive of general culture studies, as the course in architecture in the University of Illinois, include such subjects as the history of architecture, which is itself a most liberal and suggestive subject; for the spiritual ideals and aspirations of an age embody themselves in the architecture, and the history of architecture is in some large degree the history of the race.

J. M. Hamilton, of Montana, presented the following paper:

RELATIVE AMOUNTS OF PURE AND APPLIED SCIENCE IN THE LAND-GRANT COLLEGES.

The central thought in the title is science. Science in its broadest significance and widest meaning embraces all classified and organized knowledge. For the purpose of this discussion the scope of science will be limited to the knowledge of the forces and materials of the natural world. Such sciences as philology, metaphysics, etc., will not be considered as properly within the field of this inquiry. The mathematical, physical, and biological sciences will be deemed sufficiently comprehensive to mark a bound to the limits of this paper.

Furthermore, only that will be called "science" in which the factors of cause and effect are so completely known that before a theory is applied to a definite problem the results can be predicted with reasonable certainty. That part of astronomy which applies to eclipses is science. The kind, time, duration, and locality of an eclipse can be predicted with absolute certainty many years in advance, for all factors influencing the astronomical phenomenon known as an "eclipse" are known. The weather can not be forecasted with the same degree of certainty twenty-four hours in advance. Evidently there are forces at work in climate not yet fully understood. Meteorology has not attained the same degree of scientific perfection as astronomy. Communication between mind and mind happens occasionally, apparently without the ordinary media of thought transference. A theory of mental telepathy has been hypothesized upon these unexplained occurrences; but when a favorable environment is arranged and the telepathic message is started it so seldom reaches the intended destination that all claims to mental telepathy being a science fall to the ground.

By placing this limit upon the meaning of the word science an enormous amount of rubbish that frequently is exploited as science and often masquerades under the name is disqualified, and the discussion is thereby clarified. It is perfectly competent and highly desirable for investigators, teachers, and advanced students to labor with this undifferentiated mass of undigested material; for it is by such research that the boundaries of science are pushed back, and without empirical work little or no progress is possible in the increase of scientific knowledge. It is a question whether or not the average undergraduate student should be set to work upon those problems whose only claims to science are supported by nothing better than tradition, assertion, or opinion.

Science, as used in the title of this paper, is limited and qualified by the terms "pure" and "applied." In a legitimate sense all science is pure, in that it is truth; but for the purposes of this discussion pure and applied science will be considered mutually exclusive. Pure science is that part which has not been put to any economic use. Applied science is that part which has been utilized in the solution of the problems and situations of life. The effect of water upon plant growth is scientific knowledge which is directly applied in the economy of the world's food supply. A knowledge of the composition, size, and movements of the star Sirius does not affect the daily life of any. Between these two extreme examples there are thousands of other cases, shading imperceptibly into each other. The line of demarcation between pure and applied science is neither definitely nor permanently drawn. To-day some fact of supposed applied science proves unworkable and is relegated to the domain of pure science; to-morrow some concrete application is discovered for a hitherto wholly abstract principle. Perhaps the motive furnishes the best basis for classification. Scientific research that is carried on for the acquisition of truth only and the mere sake of extending the boundaries of knowledge is pure science. Scientific experiment conducted with the immediate end in view of utilizing the results in an economic problem is applied science. The factor of utility marks a fundamental difference between them.

A third limitation placed upon the discussion requires that it apply to the institutions represented in this association. This phase of the question necessitates an inquiry into the field and function of the land-grant colleges. Did Congress intend to duplicate the work of institutions then existing and equipped? Or did it propose to found a system of colleges to supplement some deficiency in the American educational system and duplicating, in part, established institutions of higher learning? Or was the aim to create an entirely new kind of college? Is the field of the land-grant colleges definite, special, and limited? In 1862 colleges and universities of diversified characteristics afforded American students varied opportunities for education. A few had been founded and endowed by philanthropists and were representative of the views of their individual promoters. Many were maintained by churches and were working out the ideals of their respective denominations. Some were State institutions and corresponded to the peculiar notions of particular States. What, then, caused the Congress to found a system of colleges distributed throughout the entire number of States and Territories, governed by a common law, and supported in part by national resources? Prior to this time the maintenance and control of public education had been considered the exclusive prerogative of the States. Evidently to the minds of the representatives of the people something was lacking in the work of existing institutions. In some respects none of them met the full, rounded, complete educational ideal of the nation. This was no freak measure, railroaded through Congress without due consideration. Several years of agitation, a number of defeats, including one Presidential veto, preceded the passage of the first Morrill Act. It was no sporadic effort, but an intelligent, persistent, national movement; was not representative of any individual cult or religion. Fortunately, the purposes and functions of the proposed institutions were concisely and definitely set down in the law, and there is small need for mistaking them.

It is only fair to assume that the lawmakers meant what they said; that they expected the usual rules of interpretation to be applied to the language of the law. The familiar and oft-quoted passage of the first Morrill Act contains some remarkable propositions. Five things stand out prominently in this declaration of educational principles: (1) Land-grant colleges were to be colleges, not elementary schools, not universities. The term "college" at that time had a well-known and definite meaning. Whatever the name attached to any particular institution, the work should reach college rank and grade. (2) "The leading object should be to teach such branches of learning as are related to the agriculture and the mechanic arts." "Other scientific and classical studies," while not excluded, were made secondary. (3) These subjects were to furnish both "a liberal and a practical education." It would not be necessary to pad the curriculum with the so-called "culture studies" to provide the liberal element. Agriculture, mechanic arts, and related subjects should do this. (4) These institutions were established especially for the industrial classes—not the poor alone, for the rich labor equally, and frequently more assiduously than the poor; nor the manual laborer only, but all whose labor bears directly upon the industrial development of the nation. (5) The training provided by these colleges should not only prepare for a pursuit, a vocation, but should rise to the dignity and the proportions of a profession.

The disposition of these colleges should be in such manner as the legislatures of the States should respectively prescribe. A land-grant college might constitute a unit in some great State university like Minnesota and California; or it might be united with a private foundation as at Cornell and Purdue; or it might be a part of a standard college, where the State provides for instruction in "other scientific and classical studies," as at Pennsylvania State College; or it might be an institution where chiefly subjects relating to agriculture and the mechanic arts are taught, as at the Michigan and Kansas agricultural colleges.

Twenty-eight years after the passage of the first Morrill Act and after these land-grant colleges had passed the experimental stage, the representatives of the people in Congress, in response to a popular demand, further endowed these colleges by an annual, direct appropriation out of the National Treasury. This second Morrill Act specifies the purposes for which this money may be expended, and this may consistently be considered a reiteration and an interpretation of the former law. This second declaration is notable for two things: First, it names the subjects for which instruction and equipment can be provided out of this national appropriation. Again, agriculture and the mechanic arts, like the name of Abou Ben Adam, lead all the rest. The related subjects are named as "the English language, and the various branches of mathematical, physical, natural, and economic science." Second, applied science is too dominant, for the law directs that the subjects named are to be taught with special reference to their application in the industries of life. These restrictions were intentional and premeditated, for the bill passed the Senate without them and they were inserted by amendment in the House of Representatives.

In 1862 less than a score of institutions of any rank were offering courses in the mechanic arts and much that was given was not above the grade of the high school manual training of to-day. Now, State, denominational, and private colleges and universities are eagerly searching for funds with which to establish and maintain departments of engineering and schools of technology. Then scarcely a half dozen institutions offered work in agriculture. Text-books in scientific agriculture had not been written; teachers had not been trained; courses of study had not been arranged; in fact, there was no science of agriculture. To-day agronomy, animal husbandry, and plant breeding rank with chemistry, physics, and biology as sciences. No other class of institutions has exerted such widespread influence upon the entire educational system of our country as these land-grant colleges. This influence, trickling down into the high schools, and even common schools, has besprinkled them with manual training and is now inoculating the rural schools with elementary agriculture. They are furnishing from among their graduates and faculties a goodly portion of the splendid army of workers in the Department of Agriculture. They have inspired the Government to plant by their sides the experiment stations, the grandest agencies for research work ever conceived and put into operation. To indicate the extent to which these institutions have pervaded and dominated the educational thought and ideals of the country it is only necessary to mention the fact that in 1905 the entering class in the Sheffield Scientific School was just about as large as the freshman class in Yale University. The record is all the more notable, because during the early history of these colleges the belief was almost universal among educators that science furnished an inferior training, and that the large element of utility in applied science rendered it almost worthless for educational purposes. Many of the instructors were saturated with this notion. Betrayed in its own house, industrial education was tolerated only because of the students it might attract and the appropriations which might be secured from granger legislatures.

In considering the relative amounts of pure and applied science in these land-grant colleges, preparatory values first attract attention because preparatory values are fundamental and primary. The foundation is unquestionably of first importance in the construction of any building. It is true that the foundation incloses no bedrooms, no kitchen, no parlor. It is usually deep in the ground, under the floor hidden by porches and accessories. But there it stands, and the entire building rests upon it for permanency, stability, and usefulness. Learn a lesson from the wise man "which built his house upon a rock: and the rains descended and the floods came, and the winds blew and beat upon that house and it fell not: for it was founded upon a rock:" and the foolish man "which built his house upon the sand, and the rains descended, and the floods came, and the winds blew and beat upon that house, and it fell." That engineering which is not well buttressed upon a massive foundation of pure mathematics is not worthy the name. Trigonometry and calculus must precede surveying and hydraulics. The animal breeder must first be a zoologist. The electrician must be prepared in the physics laboratory. Just as the lawyer who passes over the principles of common law and reads only the book of statutes is never more than a pettifogger, and the physician who neglects anatomy for the study of drugs is always a quack: so the agriculturist who is not grounded in theoretical chemistry and biology is but a plowman and a herder. "First the blade, then the ear, then the full corn in the ear." First the botanist, then the horticulturist, then the creator of new fruits. The civil engineer may pick up some knowledge of surveying in the field, but calculus never. The electrician may learn to operate a dynamo and motors by being connected with a power plant, but he will not absorb his physics in that way. The agronomist may acquire some knowledge of the analysis of soils while working with his crops, but he must get his principles of chemistry in the laboratory.

There will always be a large field for the so-called short courses in agriculture, domestic arts, and engineering. Such work, however, is intended for mature persons only, men and women who have passed the usual student period of life and are already in some vocation. The function of the short course is to improve those who are at work. These elementary courses, which extend over a few weeks, or months at most, can have but little of pure science in them. Such courses should be recommended to young people, if at all, with the aim of getting them into school, trusting to interest them in education and to influence them to go on to something higher and better.

The four-year courses in the land-grant colleges are to furnish the same liberal training as the literary and classical courses in other colleges. They are to give the same professional efficiency in agriculture and engineering as do schools of law and medicine. They must rest upon a four-year preparation. This preparation must be strong in algebra, geometry, physics, biology, and chemistry. Pure mathematics and pure science must hold a commanding position during the first half of the college courses. But it is just as grave an error to give nothing but pure science to prospective scientific agriculturists and engineers as it is to give none at all. Pure science is not in the curriculum because it affords a superior training, but for the very utilitarian reason that it is absolutely essential as a preparation for applied science. Pure science is narrow, isolated, and gives but a partial view of any applied-science problem. Applied science is cosmopolitan, comprehensive, and connected. Let me illustrate. Soil fertility, which is an applied science, embraces parts of the four pure sciences—chemistry, physics, bacteriology, and ecology. The chemist analyzes the soil and discovers what elements are lacking and what fertilizers should be applied. But, like one test for a poison, this may or may not reach the problem. And so while an agronomist must be a chemist a chemist is not necessarily an agronomist. The physicist prescribes a treatment for the soil which will enable the air to circulate freely through it and conserve the moisture. He gives direction as to methods of cultivation, summer fallowing, plowing under green crops, and breaking up the capillaries. But he sees but that one phase of the problem. Soil fertility is more than physics. The bacteriologist makes his diagnosis. He discovers nitrogen-fixing bacteria in the roots of leguminous plants and that the success of crop rotation with clover and alfalfa is due to the presence of these bacteria. He prepares to inoculate the soil with the germs, and bacteriology becomes a factor in soil fertility. Last comes the ecologist and takes up the questions of mixed crops, cover crops, rotation of crops, and weeds. And thus parts of four pure sciences combined in the right proportion make up the one applied science of soil fertility. But four men working separately, each along his peculiar line of research, would never solve the problem, but one man combining work from the four view points will succeed.

The problem of irrigation is likewise composite. The civil engineer builds the ditch and constructs the head gate. He can measure the water that passes through the weir. But the agriculturist must give instruction as to the relative amounts of water required by different crops and different soils, how often the water should be put on, and at what season of the year, for he understands the effect of water on plant growth. But now the seepage water begins to evaporate on the next field below and brings to the surface the alkali of the soil. Immediately the chemist is requested to make an analysis, and the result foreshadows the ruin of the field. The civil engineer is recalled to put in a drainage system which will draw off the water turned on at the head gate.

A new insect pest appears in the cotton region, and at once the entomologist begins a series of experiments to determine the best method of limiting the affected area and ultimately to destroy the pest. At the same time the plant breeder undertakes to produce a variety of cotton with sufficient power to resist the pest. Each problem in applied science is complex and composite. It is the function of applied science to organize the separate facts of pure science into a coherent whole. Each individual science yields a part of the case, which, like any other half truth, may have the effect of a falsehood. A point is finally reached when the mathematician must either become an engineer or turn over his work to an engineer. The botanist must do likewise with the horticulturist. Every director of applied science has experienced trouble because the chemist climbed over into the field of the biologist or the botanist undertook the solutions of problems properly within the province of the bacteriologist, strife and duplication being the result. The solution of this vexed question involves the training of men of sufficient breadth to handle such problems as animal and plant breeding, soil fertility, and irrigation in their entirety. Even though these men only superintend the work, they must have the broad training.

The discipline derived from the study of any subject is of vital value. In judging any mental work a first consideration is power to produce scholars with the ability to do things. Until recently the formal discipline theory supplied the controlling principle in curriculum construction. The friends of this theory maintained that just as a man might accumulate capital in a factory and afterwards employ it in banking or commerce, so the student might develop skill in the study of the classics, which could afterwards be used in constructing a railroad, superintending a mine, or managing a ranch. Now, it is seriously questioned if there be any such thing as generalized habit. The habit of neatness in manuscripts acquired by the teacher of English does not always extend to his personal appearance. The habits of order and exactness shown in the class room of the mathematics teacher need not appear in his business affairs. Every athlete shows that the training necessary to develop the burst of speed of the sprinter will not create the endurance of the long-distance runner. Skill in the observation of the parts of a plant gives no assistance in mastering the letters of a word in spelling. Committing history names renders no aid in remembering scientific terms. Ability to interpret poetry yields no help in the interpretation of a scientific problem. No one expects a fish to live on land when the pond goes dry, nor the blacksmith who has lost his job to enter the employ of a cabinetmaker. The old educational maxim, " Learn to do by doing," needs no revision. If you want to learn to swim, jump into water, and waste no time climbing mountains; if you expect to fight in a modern army, get behind a Mauser rifle and take no chances with a leather shield and wooden spear.

Any so-called scientist can discourse as learnedly as Weismann upon the theory of heredity, but real business begins when the theory is put to the test in stock and grain breeding. It is of small consequence to a boy, set to determine the dimensions of the boards for the construction of a box, what answer he gets if the matter extends no further than a few figures on a slate which may be erased with a drop of water; but it is an entirely different affair when he takes a saw and a board and must cut them out. One man's guess at the weight of a cow is as good as another's until she is driven upon the scales. The student in trigonometry may not get beyond the diagrams and letters until he undertakes surveying. A school boy at Eton wrote upon the door of the Greek room, "This road leads to nowhere," and the professor aptly replied below, "But nevertheless a very good road for exercise." Who has not watched the first football eleven at signal practice? What an impregnable line! What perfect interference! But horrors, a few minutes later when the game begins, what breaking through the line! What smashing of heads and interference! The first is exercise, the second the real game.

Darwin in twenty-eight years of observation never proved that his theory of slow and gradual changes through environment would account for the origin of species. But De Vries quickly established his mutation theory in the greenhouse and nursery. The former held that monstrosities would not perpetuate their peculiar characteristics, and thus would become extinct; the latter showed that radical departures from the type fixed their individual qualities in their offspring. These observations are not offered as an argument against the study of classics and metaphysics. Neither are they intended to discredit pure science. The aim has been to secure a place in the household of disciplinary subjects for applied science.

The adjudication of the claim of pure and applied science in the curriculum of the land-grant colleges necessarily raises the question of the utilitarian value of knowledge. Educational values are subject to the same laws as commercial values. This statement will sound sacrilegious to many. Some will claim that there is a residue in education that escapes the tapeline of the practical man and refuses to be measured in terms of money. This position is a sentiment, a satisfaction, a joy, a culture. It prefers frayed clothes, chilly garrets, and cold potatoes; and this is proper enough for the eccentric few. Generally this same culture composes a poem and the friends of the author subscribe for enough copies of a de luxe edition to scare away the wolf; or writes a lecture and negotiates with some Young Men's Christian Association to exploit it at so much per night. There is an educational market just as surely as there is a grain market. In this market the venders and purchasers of educational wares meet to barter. Here the author with his story meets the reading public; the architect finds a contractor; the engineer consults the railroad promoter, and the doctor and the lawyer offer their services to the sick and those in trouble. Here Emerson brought his first volume of essays along with Morse and his electric telegraph. Here Walt Whitman offered his rhymeless poems and Edison his dynamo. Here some representative of the impressionist school of art will present a picture in competition with Burbank's latest creation in fruit. There is no virtue in any subject per se. There is much hypocrisy in the slogan, "Art for art's sake, work for work's sake, science for science's sake.' There is no innate worth in wearing rags and going hungry. Rather a thousand times Mrs. Wiggs, with her half a score of urchins in the cabbage patch, than Thoreau, with his penny a day, living at Walden Pond. To-day the Titans of science are such men as Luther Burbank, in his California nursery; Perry G. Holden, in an Iowa cornfield, and Thomas A. Edison, in an electrical laboratory. These men represent a type of scientists who are professedly applying science, but at the same time pushing the boundaries of pure science back at a dizzy rate. While the Germans have increased the average percentage of saccharine matter in the sugar beet from 12 to 18, they have multiplied the knowledge of plant growth. While corn breeders have been running the comparative amounts of oil and protein up and down, they have been completing our fragmentary knowledge of the influence of heredity and environment upon plant life. While the problems of soil fertility are being worked out with nitrogen-fixing bacteria and the pulse family of plants, great progress is being made in conquering the mysteries of bacteriology. While electrical engineers are devising new means of utilizing electricity as a form of power to provide the comforts of life, wonderful theories are being constructed as to the very constitution of matter. Just as all honest and well-directed labor is respectable, timely, and essential, so all science rightly applied to the advancement of human civilization is profitable, honorable, and effective.

In conclusion the following sums up the points of the discussion:

(1) The land-grant colleges are essentially schools of applied science. This is necessarily true of any institution where the leading object is "to teach such branches as are related to agriculture and the mechanic arts in order to promote the liberal and practical education of the industrial classes." Applied science is emphasized by the law which directs that the largest Federal appropriation shall be used only for "instruction in agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural, and economic science, with special reference to their application to the industries of life and to the facilities for such instruction." The history and evolution of these colleges has been in accord with this spirit. Whether separate institutions or colleges in universities, wherever the Federal funds are being expended and the work authorized and required by the two Morrill Acts is being done, there is a center of applied science, an industrial school.

(2) A large amount of high-grade pure science is essential as a preparation for the applied science. Engineering must be based upon thorough work in geometry, trigonometry, and calculus. Agriculture must rest upon a firm foundation of biology, physics, and chemistry. This pure science work is provided not because it furnishes a training superior to surveying, mechanics, horticulture, and animal husbandry, but because pure science is a preparation for applied science. A four-year preparatory course containing a large portion of mathematics and science should be a prerequisite to all college courses in agriculture and the mechanic arts. Low standards encourage the engineering work to degenerate to the level of manual training and agriculture to become mere nature study. Pure science should dominate the first year of all the college courses. The second or sophomore year is early enough to begin specialization.

(3) The science work of the last half of the college courses, whether in agriculture or in engineering, should be thoroughly industrial. The problems of applied science are complex, composite, and comprehensive. They cover a wider range than any one pure science. A chemist or a biologist is not so well fitted to superintend plant breeding, animal breeding, soil experiments, etc., as one trained in horticulture, animal husbandry, etc. The teacher of pure mathematics does not presume to direct the work in civil, electrical, or other engineering. The two cases are parallel. It is because of the supplementing of pure mathematics by extensive training in hydraulics, machinery, electrical manipulations, etc., that engineering has reached the dignity of a profession and ranks with law and medicine. Scientific agriculture is fast approaching the same proportions through the work of the instructors and station workers in the land-grant colleges.

(4) The disciplinary value of any subject is a proper question for consideration in the construction of courses of study. The best thought of the day—and this view is confirmed by practice—seriously questions if the mental training acquired in one subject can be transferred to another. The best way to learn to do a thing is by doing that thing. Just as a mediocre carpenter can build a much better house than a first-class tailor, so each subject is incomparably the best trainer for its own work. One theory is as good as another until it is put to the test. In fact, the chief claim of some theories is that they can never be applied sufficiently to disprove them. The influence of heredity and of environment can be worked out only in the field, the nursery, the greenhouse. Practice makes perfect, and applied science is practice.

(5) The fact that the product of a piece of work can be put to some use does not necessarily degrade that work. Utility is not a synonym for unworthiness. There is an element of sacrifice in all training. No cow can produce the maximum of both milk and beef. No corn can yield the highest per cent of both oil and protein matter. Darwin bemoaned the fact that while he studied science he lost the power to appreciate poetry. But what Darwin sacrificed the world gained, for without those years of single-purpose labor the nineteenth century would not have been enriched by that master work, the Origin of Species.

Finally, there is no antagonism between pure and applied science, for applied science is simply carrying pure science out to its legitimate fruitage. Pure science has enriched applied science with some valuable discoveries. No doubt when applied science is better organized and more generally pursued it will return the favor. If the land-grant colleges are true to the ideals expressed in their charter laws, if they are true to the needs of their several immediate communities, if they are true to the spirit of industrial education, they will hold and increase their present leadership in the scientific development of the economic resources of this great country of ours.

COURSES IN AGRICULTURE, HORTICULTURE, AND ALLIED SUBJECTS.

F. W. RANE, of New Hampshire. A committee was appointed two years ago by the section of horticulture and botany of this association to outline courses in horticulture, and I happened to be made chairman. The other members of the committee were F. A. Waugh, of Massachusetts; J. Craig, of New York; R. S. Mackintosh, of Alabama, and U. P. Hedrick, of New York. The officers of the section on college work and administration have asked me to carry out that idea, also adding some other features. In the first place, we are all aware of the excellent work that has been done by the standing committee of the association on methods of teaching agriculture. Their reports have been printed,[a] and I have taken the course they recommend as a basis of the agricultural work. In the agricultural course recommended by that committee there are 180 hours that are designated for horticulture and forestry. Our committee, after looking over this course of 180 hours, has subdivided the subject of horticulture as follows:

HORTICULTURE—180 HOURS.

	Hours.
Propagation	20
Pomology (fruit growing)	50
Olericulture (vegetable gardening)	50
Floriculture (flowers and decorative plants)	30
Landscape horticulture	30
Total	180

The committee concluded that it was best to give a course in propagation, which really applies to all the various subdivisions that are given—pomology, olericulture, floriculture, and landscape horticulture—and therefore outlined a course in propagation, as follows:

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[a] U. S. Dept. Agr., Office of Experiment Stations Circ. 55.

HORTICULTURE, I. PROPAGATION—20 HOURS.

Propagation.
- By seed
  - Longevity of seed.
  - Storing seeds.
  - Testing seeds
    - In soil.
    - Artificial medium.
  - Sowing seeds
    - Time.
    - Seed bed.
- By division
  - Detached parts
    - Specialized buds
      - Bulbs.
      - Bulblets.
      - Cormbs.
      - Tubers.
    - Sections of the plant
      - Cuttings
        - Tuber.
        - Root
        - Stem
          - Greenwood.
          - Hardwood.
        - Leaf.
      - Grafting
        - Cleft.
        - Whip.
        - Veneer.
        - Saddle.
        - Splice.
        - Bark.
        - Inlaying.
        - Seed.
      - Budding
        - Shield or T.
        - Ring.
        - Prong.
        - Plate H.
        - Flute.
        - Clip.
  - Parts intact
    - Suckers.
    - Stolons.
    - Layers.
    - Approach-grafting.

Twenty hours is not a great amount of time for this subject, but for the student taking a four-years' course in agriculture this will cover propagation fairly well. We next allow pomology 50 hours out of the 180 hours.

HORTICULTURE, II. POMOLOGY—50 HOURS.

- Introduction
  - Definitions.
  - Place in general horticulture.
  - Recent development as an industry.
- Classification of fruits
  - Orchard.
  - Vines.
  - Small.
  - Nonwoody or herb-like.

- ORCHARD FRUITS
  - Pomaceous fruits
    - Apple.
    - Pear.
    - Quince.
  - Drupaceous or stone fruits
    - Plum.
    - Cherry.
    - Peach and nectarine.
    - Apricot.
  - Citrus fruits
    - Orange.
    - Lemon.
    - Lime.
    - Citron.
    - Shaddock, etc.
  - Nut fruits (nociculture)
    - Walnut.
    - Butternut.
    - Pecan.
    - Hickory.
    - Chestnut.
    - Filbert and hazel.
    - Almond, etc.
  - Palmaceous fruits
    - Cocoanut.
    - Date, etc.
  - Miscellaneous
    - Persimmon.
    - Olive.
    - Pawpaw.
    - Fig.
    - Mulberry.
    - Pomegranate.
- VINE FRUITS (VITICULTURE)
  - Table grapes
    - American origin.
    - Foreign origin.
    - Hybrids.
  - Wine grapes.
  - Raisin grapes.
- SMALL FRUITS
  - Bush fruits
    - Raspberries.
    - Blackberries.
    - Currants.
    - Gooseberries.
    - Juneberries.
    - Buffalo-berry.
    - Dewberries.
  - Strawberries.
  - Cranberries.
- NONWOODY OR HERB-LIKE FRUITS
  - Banana.
  - Pineapple.
  - Prickly pear.
- Syllabus to be followed with each group, crop, or individual plant.
  - Botanical knowledge.
  - History.
  - Importance and extent of cultivation.
  - Soils and locations.
  - Plant food (fertilizers).
  - Propagation.
  - Planting.
  - Culture.
  - Training.
  - Pruning
  - Thinning.
  - Picking (harvesting).
  - Marketing.
  - Storing.
  - Varieties.
  - Spraying
    - For insects.
    - For diseases.
  - Profits (estimated).

NOTE.—Lectures, recitations, and laboratory exercises are to receive their due apportionment with all the crops.

Following pomology comes olericulture (vegetable gardening), to which 50 hours are given. This subject is subdivided somewhat as pomology.

HORTICULTURE, III. OLERICULTURE—50 HOURS.

- INTRODUCTION
  - Definitions.
  - Place and importance in horticulture.
  - Recent developments as an industry.
- GARDENING, KINDS OF
  - In the open
    - Natural.
    - Under irrigation.
  - Under glass
    - Cold frames.
    - Hotbeds.
    - Glass structure
      - Heat
        - Fermenting materials.
        - Hot air.
        - Hot water.
        - Steam.
      - Houses
        - Even span.
        - Shed roofs.
        - Two-thirds span.
        - Three-fourths span.
        - Miscellaneous.
  - Seed growing
    - Private use.
    - Commercial use.
- CLASSIFICATION OF VEGETABLES
  - Root crops and tubers.
  - Alliaceous group.
  - Leguminous group.
  - Brassicaceous group.
  - Solinaceous group.
  - Cucurbitaceous group.
  - Salad plants and pot herbs.
  - Miscellaneous vegetables.
  - Sweet herbs.
  - Mushrooms.
- ROOT CROPS AND TUBERS
  - Potato.
  - Sweet potato.
  - Radish.
  - Beet.
  - Parsnip.
  - Carrot.
  - Turnip.
  - Horse-radish.
  - Salsify and scorzonera.
- ALLIACEOUS GROUP
  - Onion.
  - Leek.
  - Garlic, chives, etc.
- LEGUMINOUS GROUP
  - Peas.
  - Beans.
- BRASSICACEOUS GROUP
  - Cabbage.
  - Kale.
  - Brussels sprouts.
  - Cauliflower.
  - Broccoli.
  - Kohl-rabi, etc.
- SOLINACEOUS GROUP
  - Tomato.
  - Eggplant.
  - Peppers.
  - Physalis.

CUCURBITACEOUS GROUP	Cucumber. Muskmelon. Watermelon. Squash. Pumpkin, etc.
SALAD PLANTS AND POT HERBS	Spinach. Lettuce. Cress. Corn salad. Endive. Chicory. Dandelion. Mustard. Chard. Sorrel. Parsley. Rhubarb.
MISCELLANEOUS VEGETABLES	Celery. Celeriac. Asparagus. Sweet corn. Okra, or gumbo. Martynia. Artichoke.
SWEET HERBS	Sage. Lavender. Peppermint. Catnip. Caraway, etc.
MUSHROOMS	Edible species.
Syllabus to be followed with each group, crop, or individual plant	Botanical knowledge. History. Importance and extent of cultivation. Soils and locations. Plant food (fertilizers). Propagation. Planting. Culture. Training. Pruning. Thinning. Picking (harvesting). Marketing. Storing. Varieties. Spraying for insects. Spraying for diseases. Profits (estimated).

NOTE.—Lectures, recitations, and laboratory exercises are to receive their due apportionment with all the crops.

Floriculture is given 30 hours, and is subdivided as follows:

HORTICULTURE, IV. FLORICULTURE—30 HOURS.

INTRODUCTION	Definitions. Place in general horticulture. Value in illustrating intensive agriculture. Relation to landscape gardening.

- Kinds of work
  - Out of doors.
  - Under glass
    - Greenhouse construction.
    - Greenhouse management.

- Greenhouse construction
  - History and evolution of glasshouses.
  - Types of houses
    - The lean-to.
    - The even span.
    - The three-quarter span.
    - Curvilinear roofs.
    - Houses for special crops.
  - Building materials
    - Foundations and walls.
    - Walks and benches.
    - Roof structures.
    - Glazing.
    - Ventilators.
  - Heating
    - Steam.
    - Hot water.
    - Furnace.
    - Piping.
    - Fuel.

Commercial cut flowers: Rose, carnations, violets, chrysanthemum, sweet peas, etc.

Bulbous and tuberous plants: Narcissus, lilium, hyacinth, cyclamen, filesia, jonquils, etc.

Ornamental foliage plants: Palms, ferns, croton, dracæna, maranta, araucaria, selaginella, pandanus, etc.

Ornamental flowering plants: Azalea, cineraria, primula, genista, fuchsia, etc.

- Bedding plants
  - Bulbous: Cana, tulip, crocus, caladium, begonia.
  - Not bulbous: Geranium, coleus, salvia, ageratum, alternantheræ, iresine.

- Orchids
  - Terestrial.
  - Epiphytal.

- Aquatics
  - Nymphea.
  - Nelumbium.
  - Victoria.

- Cacti
  - Opuntia.
  - Cereus.
  - Phyllocactus.

- Syllabus to be followed with each group, crop, or individual plant.
  - Botanical knowledge.
  - History.
  - Importance and extent of cultivation.
  - Soils and locations.
  - Plant food (fertilizers).
  - Propagation.
  - Planting.
  - Culture.
  - Training.
  - Pruning.
  - Thinning.
  - Picking (harvesting).
  - Marketing.
  - Storing.
  - Varieties.
  - Spraying
    - For insects.
    - For diseases.
  - Profits (estimated).

NOTE.—Lectures, recitations, and laboratory exercises are to receive their due apportionment with all the crops.

To the last division, landscape horticulture, 30 hours is given.

HORTICULTURE, V. LANDSCAPE HORTICULTURE—30 HOURS.

The committee had difficulty in deciding upon an outline for landscape horticulture, so it was decided to assign 30 hours for that subject without an outline.

OTHER FEATURES OF THE COURSE.

There are a few features which we wish to bring up for discussion. In the first place, referring to the course recommended by the committee on methods of teaching agriculture, you will see that in the freshman year 150 hours are given to physics, 150 hours to chemistry, 155 hours to geometry and trigonometry, 120 hours to English, and 180 hours to modern languages, etc., as follows:

Agricultural course in college.[a]

Freshmen.		Sophomores.		Juniors.		Seniors.	
Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.
Physics	150	Agriculture:		Agriculture:		Agriculture:	
Chemistry	150	Zootech. 60 Agron. 90	150	Agron 50 Zootech. 100	150	Dairying 70 Farm mechanics 60 Rural economics 60	190
Geometry and trigonometry	155	Meteorology	60	Geology	120	Veterinary medicine	180
English	120	Agricultural chemistry	180	Botany	60	Horticulture and forestry	1 0
Modern language	180	Botany	120	Physiology	180	History and political economy	190
		English	80	Zoology	120	Ethics	40
		Modern language	100	Psychology	60		
		Drawing	60	Modern language	60		
	755		750		750		780

[a] A general outline of this course, without reference to its division according to years, was given in the second report of this committee. (See U. S. Dept. Agr., Office of Experiment Stations Bul. 49 and Circ. 37.) The number of hours assigned to each subject includes the time given to laboratory exercises, each of which would occupy two hours. Thus, for example, 150 hours of physics may be divided into 60 lectures or recitations and 45 (=90 hours) laboratory exercises. Our committee has not attempted to say how the time should be divided between lectures or recitations and laboratory exercises, but presupposes that a reasonable number of laboratory exercises or practicums will be given in all the science courses.

A committee on courses in botany, which reported to this association two years ago, recommended that this subject be given 240 hours instead of the 180 assigned in the above outline. Botany, as the table shows, begins in the sophomore year and ends in the junior year. Horticulture is largely economic botany. It is absolutely necessary that horticulture should have a good foundation in botany, and if the botany is not begun until the sophomore year and is finished in the junior year, of course it is impossible to get horticulture until the last or senior year.

I appreciate very much the work that the committee has done in recommending this course in agriculture. I do not care to criticise this course in any way, but, looking at it from a horticultural standpoint, I wish to bring out some of the features that the horticultural men of this committee criticise, respecting the question of horticulture. We are fairly well satisfied, in a way, with 180 hours for horticulture, but we do not like its placing in the course. Also, the course is not elastic enough for one bearing so general a title. Horticulturists feel that they are interested in the general agricultural course as much as the agriculturists. In fact, it seems the time has come when the professor of agriculture has no particular monopoly upon the agricultural course any more than the professor of horticulture, or any more than the professor of animal industry or dairying, or many of the other lines. The professor of horticulture is interested in giving horticulture earlier than the senior year. It often happens that in many of our institutions men graduating in agriculture are prepared and do go out, after their general agricultural course, as professors of horticulture, and they are fairly well prepared for that work. Therefore the committee as a whole would recommend that the horticulture begin earlier in the course, and thus give the men an opportunity to specialize, if they want to, in the senior year. In order to do this it is necessary to put the botany earlier in the course (see p. 88).

A COURSE IN HORTICULTURE.

The programme committee of this section asked me also to outline an ideal course in horticulture. I conferred with the various members of the committee, and we have gotten together a course which is based entirely upon the "agricultural course" before given. The idea is to give a course in horticulture exactly parallel to that in agriculture, except that a man starts out in the freshman year with the idea of finishing a four-year course in horticulture. This course includes, as will be shown by comparison, all of the principal fundamental subjects found in the other course, but arranged to suit horticulture.

Horticultural course in college.

[The number of hours assigned to each subject includes laboratory exercises. The committee presupposes that lectures, recitations, and laboratory exercises will receive their due apportionment in all the science courses.]

Freshmen.		Sophomores.		Juniors.		Seniors.	
Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.
Botany	90	Horticulture (propagation)	60	Horticulture: Pomology 120 Olericulture 120	240	Horticulture: Pomology 80 Floriculture 75	155
Chemistry	150	Agriculture	60	Agriculture	120	Landscape gardening	60
Geometry and trigonometry	155	Physics	90	Geology	120	Forestry	40
Surveying	60	Agricultural chemistry	90	Botany	90	Agriculture: Rural economy 60 Farm mechanics 60	120
English	120	Botany	90	Physiology	60	History and political economy	190
Modern languages	180	Zoology	120	Psychology	60	Ethics	40
		English	80	Modern languages	60	Elective or thesis subject	175
		Modern languages	100				
		Drawing	60				
	755		750		750		780

Classification of studies.

Nature of subjects.	Freshmen.	Sophomores.	Juniors.	Seniors.	Entire course.
	Hours.	*Hours.*	*Hours.*	*Hours.*	*Hours.*
Culture	300	240	120	230	890
Pure science	395	390	270		1,055
Applied science (required)	60	120	360	375	915
Applied science (elective)				175	175
Total	755	750	750	780	

Botany is given 90 hours in the freshman year instead of beginning in the sophomore year. Chemistry is given 150 hours, as before. Physics is cut from 150 hours to 90 hours and placed in the sophomore year. Geometry and trigonometry are given 155 hours, the same as before. Surveying, 60 hours has been added. English and the modern languages remain exactly the same. Therefore the only difference is in regard to the question of pure science. We have in this case 395 hours, as compared with 455 hours of pure science in the other course. Dividing the subjects up, we have: Cultural subjects, 300 hours; pure science, 395 hours; applied science (surveying), only 60 hours. In the sophomore year we introduce the 60-hour course in propagation. We also realize that agronomy is important to the horticultural men—and this is also true of soil physics and subjects of that nature—and therefore we have given 60 hours of agronomy in the horticultural course. Agricultural chemistry we have given 90 hours, as against 180 hours. Botany we have given 90 hours. This gives 180 hours, as against 120 hours. Zoology is brought back from the junior year, considering it a primary fundamental pure-science subject, our idea being to get it in the earlier portion of the course rather than let it remain over later, because a great many of our horticultural subjects should begin in the junior year rather than later; and zoology, especially entomology, is work fundamental to these subjects. English, the same, 80 hours; modern languages, the same, 100 hours; drawing, 60 hours, the same, giving 750 hours in all. Totals: Cultural subjects, 240; pure science, 390; applied science, 120—750 hours in all. In the junior year we are prepared to begin our horticultural work, and we have pomology and olericulture, beginning with 120 hours each.

It is necessary for a student in horticulture to know something about the economic feeding of animals and breeds of animals. To meet this need agriculture, 120 hours, is added. Geology, 120 hours, the same; economic botany, 90 hours; physiology, 60 hours, reduced from 180; psychology, 60 hours; modern languages, 60 hours, both the same. This divides up the junior year into cultural subjects, 120; pure science, 270; applied science, 360 hours.

In the senior year we have pomology, 80 hours, floriculture, 75 hours; landscape gardening, 60 hours, forestry, 40 hours.

We take here again the feature of the agricultural course, which we think the horticultural man should have, and include 60 hours of farm mechanics and 60 hours or rural economics, making in all 120 hours. We leave out the dairying simply because many horticultural students do not care about the dairying. They can elect it, however, if they want it. History and political economy remain the same, 190 hours, and ethics the same, 40 hours. Then we have 175 hours for elective or thesis subjects. If a student cares to take dairying he can get it in this 175 hours, or he can select 175 hours from any other subject or subjects he wants. In fact, the electives here really give an opportunity for students to carry the agriculture in the agricultural course. This is where we feel that we can afford, after giving required studies, to allow the student to select 175 hours. There is a great advantage, it seems to us, in this. This allows a student to use his own ideas as to what he wants. Some men think we do not have sufficient of the cultural side and others of the pure science in the agricultural course. For instance, in chemistry there are 150 hours in the freshman year and 180 hours in the second year of the agricultural course. It seems to us that is not well balanced as regards chemistry. If a man wants more chemistry in this course here is his opportunity to elect it; so with other subjects. In other words, a man is given an opportunity to elect in the senior year 175 hours.

COMPARISON OF HORTICULTURAL COURSES IN DIFFERENT INSTITUTIONS.

A study of the comparative amount of horticultural work, both required work and elective work, in the agricultural courses of various institutions taken at random, for examples, New York, Illinois, California, Michigan, Pennsylvania, Missouri, Massachusetts, Ohio, and New Hampshire, shows that subjects coming under the head of horticulture in these various institutions are apparently, first, propagation, then pomology, olericulture, floriculture, greenhouse management, principles of horticulture, plant breeding, horticultural seminar, landscape gardening, handicraft, viticulture, and nut culture. They are shown in the following table:

Number of hours horticulture is required and elective in agricultural courses in various institutions.

	New York.		Illinois.		California.		Michigan.	
	Req.	Elec.	Req.	Elec.	Req.	Elec.	Req.	Elec.
Propagation		54		90	36	36	60	60
Pomology		90		126	54	54	100	100
Olericulture		18		144			60	60
Floriculture				126				60
Greenhouse management		36		90			48	48
Principles of horticulture			90	90				
Plant breeding		18		45				24
Horticultural seminar		36		45				48
Landscape gardening		72	54	54	18	18	30	30
Handicraft		36						
Viticulture				45	18	72		
Nut culture				45				
Total	00	360	144	900	126	180	298	430
Year started	Junior.		Fresh.		Junior.		Soph.	

	Pennsylvania.		Missouri.		Massachusetts.		Ohio.		New Hampshire	
	Req.	Elec.	Req.	Elec.	Req.	Elec.	Req.	Elec.	Req.	Elec.
Propagation	90	90	54	54	54	54	54	54		
Pomology	90	90	54	54	54	108	54	108	45	90
Olericulture			18	18	36	72		138	35	80
Floriculture						108		54	30	
Greenhouse management		81							30	50
Principles of horticulture							54		30	
Plant breeding		81	18	18		72		48	30	
Horticultural seminar						36				20
Landscape gardening			18	18	72	288		48		30
Handicraft										
Viticulture										
Nut culture										
Total	180	342	162	162	266	638	162	450	200	270
Year started	Soph.		Fresh.		Soph.		Junior.		Fresh.	

At Cornell horticulture is not required in the agricultural course. On the other hand, the student can elect any of the various subjects named in the adjoining column. He can elect 54 hours of propagation, 90 of pomology, 18 of olericulture, 36 of greenhouse management, and so forth.

In Illinois the only requirement is 90 hours in the principles of horticulture and 54 hours in landscape gardening. But, on the other hand, students have the opportunity of electing from many courses. Cornell gives 360 hours of horticultural electives. Illinois requires 144 in the four-year agricultural course, and they allow as elective 900 hours, the largest we have, I think.

In California 36 hours are required in propagation, 54 hours in pomology, 18 hours in landscape gardening, and 72 hours in viticulture. Therefore, 126 hours are required and 180 hours only are elective. In Michigan 298 hours are required and 430 hours are elective. In Pennsylvania 180 hours are required and 342 hours are elective. In Missouri 162 hours are required and 162 are elective. Here is an institution where all the horticulture is required in the regular agricultural course. In Massachusetts 266 hours are required and 638 hours are elective. In Ohio 162 hours are required and 450 hours are elective. In New Hampshire 200 hours are required and 270 hours are elective. It is very interesting to compare these data. If a position opens up in horticulture for a student graduating in a four-year course in agriculture—for instance, in Michigan or some other institution—he is prepared to handle it, as the work goes hand in hand with agricultural training. Other institutions do not require so much horticulture, and the graduates do not feel prepared to teach it. It seems to me that there is this to be said—that the more a man studies our agricultural courses the more he is convinced that we are in a very chaotic condition as regards the pedagogy in our various institutions. Horticulture is not the only subject that varies. It strikes me that the same thing is true to a certain extent with the amount of animal industry, agronomy, etc., in our four-year course in agriculture in various institutions. Some of the men graduating from our four-year courses in agriculture are better prepared as chemists than they are in agriculture, or perhaps, putting it more mildly, I should say that they are equally as well prepared in chemistry as agriculture. The same thing may be said of many other subjects, according to the institution in question.

A STANDARD AGRICULTURAL COURSE.[a]

After a close study of all the courses the following is offered for your consideration: The agricultural course offered by the committee on methods of teaching agriculture of this association is a strong course, and it represents a feature of development in agricultural education. But it is primarily a course for grain-growing and stock-raising agricultural men. Now, it seems to me that what we want to get at in our various institutions touching agriculture is fundamental or foundation work in botany, chemistry, physics, geology, and zoology as pure sciences. It seems to me we ought to give some sort of idea as to the amount of these fundamentals that should be required by every agricultural institution in the country. I do not see why we can not agree as to a standard in this respect. It is not my purpose, by any means, to give more chemistry than is desired, or any other pure science than is desired by scientific men generally, but to propose a standard which all men should come up to.

As far as an examination of catalogues will show, none of the agricultural colleges is following out the excellent schedule offered by the standing committee of this association. For instance, horticulture is not given 180 hours in the senior year, as recommended in this schedule. It begins in New York in the junior year, in Illinois in the freshman year, in California in the junior year, in Michigan in the sophomore year, in Pennsylvania in the sophomore year, in Missouri in the freshman year, in Massachusetts in the sophomore year, in Ohio in the junior year, in New Hampshire in the freshman year. In order to give the instructors in horticulture, forestry, veterinary science, dairying, entomology, etc., a fair chance to interest students in these particular features the electives should come earlier in the courses than the senior year. Instead of allowing the instructors in dairying to give the student 70 hours in the senior year, as required, we are giving him an opportunity to get in touch with the men with fewer hours in the junior year, so that they can develop that phase of work later if they care to. I believe in the postgraduate courses. On the other hand, the great majority of these men graduate in the four-year course, and they will not take the time and perhaps can not afford to take a postgraduate course. They should therefore have some opportunity for specializing before graduating in this four-year course. If the elementary sciences are put in the forepart of the elementary course, and the standard requirements of applied sciences in agriculture brought in by the end of the junior year, then we could give the student a right to select his own occupation and let him work out his problem for himself. The course here offered is founded on that assumption.

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[a] By the chairman of the committee only.

A standard agricultural course.

Freshmen.		Sophomores.		Juniors.		Seniors.	
Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.
Botany	100	Botany	100	Agriculture:		Rural engineering	60
Chemistry	100	Chemistry	100	Agronomy 50	190	Rural economy	60
Physics	100	Geology	100	Zootechny 100		Landscape gardening	30
Zoology	100	Physiology	100	Agrotechny 40		Plant breeding	30
Geometry and trigonometry	100	Agronomy (climate, soil, etc.)	50	Veterinary medicine	100	History and political science	190
English	100	Plant propagation	50	Surveying	40	Ethics	40
Modern languages	150	English	100	Shop work	30	Electives	370
		Modern languages	100	Forestry	30		
		Drawing	50	Horticulture:			
				Pomology 50	150		
				Olericulture 50			
				Floriculture 30			
				Landscape horticulture 20			
				Psychology	60		
				Modern languages	50		
				Elective	100		
	750		750		750		780

Classification of studies.

Nature of subjects.	Freshmen.	Sophomores.	Juniors.	Seniors.	Entire course.
	Hours.	*Hours.*	*Hours.*	*Hours.*	*Hours.*
Culture	250	250	110	230	840
Pure science	500	400			900
Applied science (required)		100	540	180	820
Applied science (elective)			100	370	470
	750	750	750	780	

The scientific way of teaching should be to have the fundamentals first, early in the course, so the others can follow them. In this "standard course in agriculture" I have placed the elementary sciences in the first two years of the agricultural course. The idea is to place botany on the same basis as chemistry. I can not see why chemistry should monopolize the agricultural student any more than botany. Botany is an elementary science, one of the fundamental sciences of agriculture, it seems to me, if anything is. Botany should begin the first year. I place all of the elementary sciences on the same basis. I have therefore given botany, chemistry, physics, zoology, geometry, and trigonometry (mathematics) each 100 hours, English 100, and modern languages 150 hours. This adds up for the freshman year as follows: Culture, 250; pure science, 500; applied science, nothing; total, 750 hours.

In the sophomore year we continue these elementary sciences—botany, 100; chemistry, 100; geology, 100; physiology, 100; agronomy (particularly climate, soil, etc.), 50; plant propagation, 50; English, 100; modern languages, 100, and drawing, 50 hours, making in all the total of 750 hours. This is subdivided, showing culture, 250; pure science, 400. We now just begin the economic or applied sciences—100 hours.

The student now has his foundation work for an agricultural course. Why give elementary A B C work up in the junior and senior years? Why not bring them back into the first two years? It may be a great deal of pure science. At the same time these sciences go hand in hand; a great many things in one subject dovetail into another after the student has finished the pure sciences. Now, what should be required in the agricultural course? Our agricultural men should have certain broad ideas of agriculture. Agriculture to-day is a broad subject. If a man is an agriculturist he ought to know not only agronomy and animal husbandry, but general agriculture. Therefore, as shown in the accompanying course, in the junior year a general foundation in applied agricultural subjects is required of all students, the number of hours given being only enough to comprehend and understand the respective subjects sufficiently to give them their due recognition in the training of an agricultural graduate. It is an advantage for the agricultural graduate to know something about landscape gardening, how to grow trees, and the adornment of grounds from an educational standpoint. Besides we have allowed 100 hours as elective in the junior year. A great many say that we do not give sufficient work in culture. Now, 100 hours will balance that up, letting each man select according to his tastes.

Passing on to the senior year, mechanics and rural economics, each 60 hours, are required, the same as in the other course, because it seems desirable for all students taking the four-year course to have these courses. Landscape gardening is given 30 hours, because it seems that every man graduating in agriculture ought to have just a taste of the esthetics of agriculture. A man ought not to know simply cows and farm crops. He ought to know something about home embellishment and about making and caring for the home. He ought to be a citizen that will lead the community in making country parks and in the question of beautifying the grounds around the schoolhouse, and have some taste in such directions which a great many of our boys will never get unless it is made a requirement. Plant breeding is given 30 hours, history and political science the same as required in the other course (190 hours); ethics, 40 hours, the same as required in the other course. We have left, after requiring all these subjects, in the senior year 370 hours to bring the schedule up to the full number of hours. This gives the student, as I have already intimated, an opportunity to continue to take any of the various subjects that he has studied or select anything new he cares for. If he wants to get more chemistry, zoology, or any of the sciences, he can do it. He can go into any of the various subjects of applied science deeper or he can go back and take modern languages or more philosophy or ethics, if he cares to, or any of the various lines in English; but, no matter what he does, he will have had a broad foundation in agriculture. Now, when he goes out to teach, be it in the common school or the high school, and no matter where he goes he knows the whole subject of agriculture as a foundation, and he can talk on dairying, he can talk on landscape gardening, he can talk on the question of veterinary medicine even; he can take up any line of horticulture; he has had modern languages; he has had, in short, the fundamentals of a good college training, and he has had an opportunity to specialize also. This plan gives the veterinarian a chance at the four-year man as well as the professor of agriculture, the horticulturist, the dairy instructor, and the instructor in forestry. They have the chance of interesting the student in their special lines as far as the 370 hours will allow. In many respects it is as valuable as a post-graduate course would be to some of our graduates.

It seems to me that if you give 150 hours in chemistry in the freshman year and 180 hours in the sophomore year, as allowed in the course outlined by the standing committee, by the time the students get ready to take up agriculture they have had an undue amount of chemistry and are not likely to care to pursue the subject of agriculture. It seems necessary to place all science on an equal footing. I think it is true we have stronger chemists to-day than we have men in other lines and that is the reason why chemistry is made so large a feature in these agricultural courses. Chemistry is one of the elementary sciences, however, the same as physics, zoology, botany, geology, etc., and should receive equal recognition at the outset.

Evening Session, Tuesday, November 14, 1905.

The section held a brief evening session to decide upon time of election of officers.

Afternoon Session, Wednesday, November 15, 1905.

The section was called to order by the chairman at 2 p. m.

Election of Members of Executive Committee and Officers of the Section.

Nominations for the executive committee being in order there were nominated W. O. Thompson, of Ohio; C. C. Thach, of Alabama; H. C. White, of Georgia; E. R. Nichols, of Kansas; L. H. Bailey, of New York, and J. L. Snyder, of Michigan. After considerable discussion as to method of voting, a blanket vote was taken and Messrs. White, Bailey, and Snyder, were declared elected.

C. R. Van Hise, of Wisconsin, was elected chairman of the section, and H. C. Price, of Ohio, secretary.

The president-elect and secretary-elect of the section were authorized to act as a committee on programme, with power to select another member, or members, if they so desired.

H. W. Tyler, of Massachusetts, presented the following paper:

WHAT IS A LIBERAL AND PRACTICAL EDUCATION FOR AN ENGINEER?

The life work of the engineer consists in the systematic application of natural forces and the systematic development of natural resources in the service of man. To be practical his education must fit him to do this most effectively. But the engineer is a man and a citizen before he is an engineer, therefore his education must also be liberal.

Our engineering colleges serve a people deeply interested in all forms of education, but particularly in the practical. Opportunities for primary and secondary education are everywhere abundant, but the quality of the work is variable, the organization of it is rather loose, and economy of time is rarely attained. As a result these colleges receive from the secondary schools every fall several thousand young men aged about 18, who have learned more or less algebra, geometry, English, and natural science, variously accompanied by Latin or modern languages, history, etc. They may or may not have learned to think logically, to observe accurately, to express themselves with clearness and force, to perform mental work with sustained concentration. If they have acquired any one of these accomplishments, we are grateful. Such is our material.

It is a well-established tradition that the course in the higher institution shall occupy four years of eight or nine months each. This is our time allowance.

In this space we must—

(1) Lay a solid foundation in mathematics and the natural or physical sciences, or both;

(2) Build a technical superstructure;

(3) Broaden and deepen and strengthen the student's faculties and character by instruction in the humanities—or, to follow the figure, we must help the student to make not merely his workshop, but his intellectual home.

The first is at once practical and liberal; the second is mainly practical, but need never be illiberal; the third is mainly liberal, but should never become unpractical.

An institution which neglects the foundation in science may be of great service, but it is only a technical school and should not be called a college; a college which is weak in the technical superstructure will attract the more ambitious students only for subsequent migration; a school of applied science which neglects the general for the professional education of undergraduate students will turn out narrow men whose professional careers will sooner or later be cramped by their personal limitations.

We are really attempting a short cut in education. The professions which were formerly called "learned" are based more or less generally on graduate study. In that part of the country with which I happen to be best acquainted this is apt to mean preparation for difficult college entrance examination at the age of 19, four years of diversion and study in variable proportions, then three years of hard work in the professional school, with self-support probable not much under 30. Highly as one may esteem this system and its products, the need of greater economy in time constitutes a more and more serious problem, for which means are eagerly sought.

For the engineers our institutions have boldly undertaken to solve the problem by combining the general and the professional, the practical and the liberal, in a single four-year curriculum. We welcome the bachelor of arts who seeks to secure our professional training in three years or even two. His education ought at the end of seven years or of six to be more broadly liberal than he could gain with us alone in four. But for many the plan has serious defects, and we do not for a moment admit that it would be profitable for engineering students generally to have become bachelors of arts first. The great majority of engineering students come, and so far ahead as the future can be estimated, will continue to come from the public high schools ready for four or five years of steady, earnest work, with the sustained incentive of professional interest.

It needs no excess of self-complacency for us to rejoice that the problem of belated graduation is one which engineering need not share with the older professions; but it behooves us not to underestimate the importance and the difficulty of our own corresponding problem—that of possibly premature specialization and graduation.

The question just how to combine our three ingredients, science, technology, and the humanities, confronts us even in the determination of our entrance requirements. How much shall we demand in mathematics, how much in physical science, how much in language and history? How shall we deal with the boy who is deficient in the latter, but is apparently qualified to succeed in an engineering course? While any answer of value must depend on local and personal conditions, I venture to say that in general it is useless to admit a candidate to an engineering college unless he can meet the mathematical requirements, that insistence upon the others may depend greatly upon the age and antecedents of the candidate, with due care not to admit students with too many conditions either for their own good or for the maintenance of standards in the collateral subjects in the preparatory schools and the colleges.

The distribution of time in the curriculum must represent the consistent working out of a logical educational theory. The student should be protected against the zeal of his teachers and his own enthusiasm by an arbitrary time limit on the amount of required work per term. The time available should then be apportioned with the utmost care among the various professional, semiprofessional, and nonprofessional subjects which seem on the whole most important and best adapted to the formation of a well-designed curriculum. The most attracive errors lie, I think, in the direction of overspecialization along technical lines. It is these which appeal most strongly to the immature student and often to the professional specialist as well. But the advantage which they may give the graduate is a short-lived one. Training in technical specialties may, if luckily chosen, stand him in good stead in five years; at the end of twenty-five years his degree of success will have depended far more on his education in fundamentals. This is the basis for one limitation of the "practical" element.

It is doubtless impossible to draw a definite boundary line between science and technology. The distinction is fundamentally a subjective one of point of view. Time was when the work of our engineering colleges was stigmatized as utilitarian and mercenary, and we must be always on our guard lest our students exaggerate the importance of immediate commercial applications of the facts and laws with which they are concerned. Our students have a natural and proper interest in their own personal welfare, but I would not for a moment admit that their whole interest in their scientific work is measured by this selfish motive. They choose their careers and their manner of education by reason of well-defined natural predilections. The utility of their studies, apart from mere personal profit, is an additional and not unworthy motive.

As to the detailed application of these principles to an actual curriculum, no college or individual may speak with authority. Each may learn something from the experience of every other. As one contribution to the subject I present an expression of opinion based on our efforts to solve the problem as it presents itself in Boston. We do not claim to have succeeded; we venture to hope we are working in the right direction.

All courses include modern languages, English literature, history, and economics. The time assigned to these is in general 27 per cent in the first two years, 17 per cent in the third year, making 18 per cent in the entire course.

This should not be understood as representing a curriculum of which 82 per cent is technical. While it is scarcely practicable to make a precise quantitative statement as to the distribution of time between general subjects on the one hand and professional on the other, I believe it is safe to say that in our own case the division would be not far from an equal one.

If I were to venture on a generalization, not intended to be in the least exclusive of others, I should be inclined to say that if a given curriculum gives half of the first year to science, including mathematics, a third to the humanities, and the remainder to drawing; if the professional work occupies one-third of the time in the second year, two-thirds in the third, and the whole in the fourth, and if the time remaining in the second and third years has been given somewhat more to science than to the humanities, the student will have fallen not far short of the golden mean of "a ilberal and practical education."

As to the distribution of time among the literary subjects, some freedom of choice may well be left to the student. He is apt to take less interest in work of this kind, and any interest he may have in a particular line should be thus fostered. The bearings of these general studies upon his scientific work should be made clear, but not unduly emphasized as the main aim. The real object is to develop mental faculties not effectively reached by other work. As a matter of course the engineer needs to be able to write his reports in good English, but this power is a small part of what the department of English may give him. His greater needs are to gain the most complete and correct appreciation he can of what the living world around him really is, of what it has been in the past, and of the relations to it of himself and his profession. He needs to know all he can learn of concrete human nature by association with his fellow-men, not alone his fellow-students, and then to pass beyond the bounds of possible personal experience into the regions of national and race experience in the light of history and economics. That study is most liberal which best liberates the mind from the limitations of ignorance, prejudice, and shortsightedness. The mind is expanded by the mastery of large ideas. It is narrowed by prolonged attention to the minute and the special. Modern science becomes more and more liberal in proportion as its subject-matter becomes systematized and coordinated by generalized laws. Such principles as the conservation of energy or natural selection are among the broadest and most liberalizing of human ideas. The engineer must occupy himself long and earnestly with details, but so, too, must the specialist in any line. The safeguard for each must lie in breadth and variety of interests.

In the comparatively short period since their foundation the engineering colleges have definitely achieved certain large results. They have gained the confidence of the industrial world by the proved efficiency of their graduates. They have won the respect of the great body of scientific men by resolutely insisting on thoroughness in scientific fundamentals as distinguished from empirical methods. They have still much to accomplish—as, indeed, have all colleges—in striving toward an ideal general education. This great problem is at once universal and individual. Every student is a special care. Every college must work out its own solution in a manner best adapted to its constituency as a whole and with as much freedom as practicable for the individual.

W. E. Stone, of Indiana, presented the following paper:

A Degree Course in Home Economics.

The extraordinary developments in scientific and technical education in recent years, in which the land-grant colleges have had so important a part, have played havoc with established notions as to curricula, degree requirements, and the relative provinces of the school, the college, and the university. The clamor against the recognition of the sciences, and, later, of the various branches of technology, as a legitimate part of a scheme of education has not yet subsided from our recollection, although no longer the subjects of serious controversy. Nowadays the student of systematic education is brought to contemplate a flood of new and strange subjects which have been injected into the curricula of schools and colleges with little preliminary digestion or correlation, and it is no wonder that one sometimes feels an honest doubt concerning the proper educational status of many kinds of instruction, of quite evident industrial application, but of remote connection with letters, arts, or sciences. From the nature of things, such examples are common in land-grant colleges which, in occupying the great fields of agriculture and the mechanic arts, have put forth a multitude of subjects for instruction in connection with the most commonplace and familiar operations of daily life, about which great numbers of people already possess some degree of knowledge and experience. It is inevitable that the right of many of these subjects to a place in the college curriculum, much less to weight in a course for an academic degree, should be questioned.

There are two phases or aspects of every art or industry, the operative, requiring manual skill, and the administrative, requiring a knowledge of and education in all of the subjects having relation to that particular art or industry. These manual operations are everywhere being constantly performed by uneducated people, with fairly acceptable results; they are not susceptible of great improvement or change, and even if they were so improved or changed they still would not require the services of highly educated operatives. Better training and greater intelligence on the part of such operatives is highly desirable, but the proper performance of these operations is not based upon an extensive knowledge of the sciences, but upon personal manual skill and experience. A certain training is desirable to prepare a boy or girl for these manual operations, and a certain other and much more comprehensive training is necessary for one who is to enter the administrative field. The one is included in our conception of the scope and purpose of manual training, trade schools, etc. The other involves the higher or professional education, and lies within the province of the college or professional school. It is not necessary or even desirable that all persons engaged in a given industry should have the same training, or that this training should be that comprehended in a college course. It follows, also, that the college, even though deeply concerned in industrial and scientific education, is not necessarily expected to train men and women in the elements thereof, any more than to include in its curriculum elementary instruction in mathematics or English. If this view is defensible, it may serve as a basis for distinguishing between those things which may or may not be considered worthy of a place in the curriculum leading to a degree in the land-grant colleges.

Personally, I am convinced that a subject which is administered solely in order to train the student to a greater degree of skill in manual operations can not consistently be included in a degree course. Examples of this kind may doubtless be found in many if not all of the land-grant colleges, but probably their sponsors would agree that these are matters of temporary expediency rather than permanent educational milestones. The question as to desirability of offering instruction in certain subjects in response to an evident need for useful training by the constituents of the college, is quite distinct from the question of what we should incorporate in a curriculum, every part of which is supposed to have weight in qualifying the student for a degree.

Public educational institutions, particularly those of such democratic character as the land-grant colleges, must give large heed to public needs. In recognition of this principle many of these colleges have been prompt to provide for their constituents instruction in a variety of subjects which were essentially manual training, and which in an ideal system of education would be relegated to secondary or even primary schools. The wisdom of this is not to be questioned. No phase of the development of agricultural education has been so well advised as the great tendency to popularize the work of the colleges, even to the extent of offering elementary instruction in college halls, but such a policy is to be approved only when it has for its ultimate purpose the broader education of the public to an appreciation of the needs for such instruction in its proper place, viz. in the elementary schools.

The Morrill Act specifies that the institutions of which it is the foundation shall be *colleges*. It behooves these institutions, therefore, to cherish college standards of scholarship, bearing in mind that the tendency in educational institutions of all grades is toward higher standards and more advanced curricula. If the land-grant colleges find it a good policy to engage in instruction in manual training, it should be for the sole reason that such instruction is not elsewhere available to its constituents. It should never, under any consideration, be regarded as a permanent part of a degree course. It would be far better, therefore, if in colleges where such subjects are offered, they were not made a part of a degree course at all, but turned over to that educational catch all the "short course;" the student in which finds his reward in the acquirement of knowledge alone without the accessories of sheepskins and degrees. It is, moreover, very doubtful whether colleges should undertake to administer such courses, even under these conditions, unless it is quite clear that the resources of the institution will permit so doing without detriment to the maintenance and development of instruction of college grade.

Degree courses in the land-grant colleges should be composed of scientific and cultural elements, and subjects which can not be shown to have some definite relation to such elements should have little or no weight therein. It is noteworthy that there are some subjects which may be classified, because of the *purpose* with which they are taught, as purely manual training; or, on the other hand, as illustrations of the sciences, with the study of which the student is engaged. For instance, shop work, planned and administered as an essential part of a course of instruction in engineering, in which it is desired to correlate all scientific knowledge of mechanisms, as regards their design, construction, operation, and efficiency, is entirely justifiable in being given a reasonable weight among the scientific elements of a degree course in engineering. But shop work, administered with no other purpose than to impart skill in the use of tools, does not belong there. Training a student to make butter simply as an industrial operation, would seem to be outside the province of a degree course, but practice in butter making as illustrative of certain scientific principles is, doubtless, properly included in a degree course in agriculture. Other examples might be given, wherein the purpose behind the administration of a given subject might be regarded as the sole reason for its retention in a degree course.

With this preliminary survey of the limitations of a degree course we may possibly obtain some clearer idea of the possibility of a degree course in household science. It is indicative of the confusion surrounding this subject that we have no general term for designating it. If, therefore, I refer to domestic science or household science or domestic economy or home economics or household economy or domestic art, as I may do indiscriminately, I mean always the same thing, viz, that field of activity, tacitly reserved for women, of feeding, clothing, nursing, sheltering, and entertaining their fellow human beings. It is a wide field beyond a doubt, and one amenable to the good offices of education of all kinds—general, technical, scientific, humanitarian, secular, religious, metaphysical, and material. Our homes are touched by all human learning, and the home maker and manager may well contemplate a broad training in preparation for all the duties and responsibilities pertaining thereto. From the educational standpoint the problem of training women for greater efficiency in the administration and execution of domestic affairs is comparable with that of training men for greater efficiency in the pursuit of farming. Both occupations are fundamentally related to the wellbeing of society; both engage the attention of great numbers of persons; both involve, in addition to manual skill, administrative ability of a high order; both involve the application of scientific principles to an unusual extent. In both we find the field already occupied by those without special education, who, in their own estimation at least, are achieving a satisfactory degree of success. As in farming, so in housekeeping there is a large amount of purely manual labor which must always be performed for small wages. Neither the character of this work nor the compensation received for it will justify a costly preparatory education. A fair degree of manual training is the most that can be expected to this end, and, indeed, is the best suited thereto. It is painfully evident that the social conditions in this country are already such that few of the native born are content to render manual service of any kind, much less to avail themselves of any systematic training for such a career.

Unfortunately for the good of society, as well as for the higher development of farming and domestic life, many are willing to boss and few to labor. To what extent our educational system is responsible for this it is impossible to say, but I am sure these conditions would be improved did our public schools concern themselves more with training children in industrial and manual operations in preparation for a career of activity which, naturally, the greater number of them will follow, and that our colleges should leave this field of instruction to the public schools and to the younger pupils therein.

In both farming and domestic affairs there are, therefore, the divisions of operation and of administration, the requirements for which are in each case quite distinct. While in many instances these two functions must be united in the same person, the decided tendency is to separate them. Preparation for the operative function is a matter of manual training and personal experience which ought to be aided by systematic school training. Preparation for the administrative side of farming or housekeeping means a wide knowledge of the sciences, arts, and letters, in general as well as in their application to the particular pursuit. This is the scope or field of degree courses as ordinarily administered in preparation for other lines of human activity, and it seems reasonable to expect a similar and consistent method in dealing with agriculture and household occupations.

Engineering colleges concern themselves only incidentally with instruction in manual operations in degree courses. They do not seek to train mechanics or artisans, but rather to train men who shall plan and administer the work which is to be performed by such. The agricultural colleges are approaching a like standard as to their degree courses, although the stage of the art and the present development of agricultural education will scarcely permit, as yet, curricula which, even in the most advanced institutions, are free from subjects of manual training character, although in the main their degree courses are composed of scientific and cultural elements.

Domestic science, as compared with agriculture or the mechanic arts, is still in the early stages of development as a field for educational effort. The situation is quite like that which existed in agricultural education in its early days, except that now the public mind is better informed as to the possibilities of technical training, and, consequently, is inclined to receive new propositions with greater sympathy and interest.

But what shall be taught under the head of domestic science; how shall it be taught; what shall be the sequence of subjects; where shall they be presented? These are all questions about which no two persons have the same opinion, and when it comes to the matter of a college course leading to a dergee in this subject it is pertinent to inquire if at the present time such a course is feasible, justifiable, or educationally wise.

It must be quite evident to every thinking person that the art of directing a household is one highly susceptible to the benefits of training and education; that a wise application of scientific principles to household management can not fail to result in better health, greater economy and happiness, and a higher plane of living, and that these conditions, in time, have their beneficent influence upon society in general. Not only can we understand these possibilities, but we can well believe the statements of those informed in such matters, to the effect that the social and moral reforms so greatly needed in certain classes are best promoted through better conditions of home life, to be gained by education and training of the most elementary sort.

It is impossible, therefore, to overlook the importance of the field, and the opportunity here afforded for an educational work of the widest scope, extending from the simplest manual training to the highest applications of learning of all kinds to a more rational development of domestic life and the home.

There is no doubt that the actual needs in this field are far beyond the capacity of existing educational facilities as they exist now or are likely to exist for a long time to come.

We shall agree that any girl who is a potential home maker should have an educational preparation for this important function, and that the elementary phases of this training should receive quite as early and weighty attention as any other. Few mothers are competent or able to do this work, and the source of this training must be found in the public schools, where all girls should have some good instruction in the manual operations of the household, such as cooking, sewing, the laundry, and the principles of sanitation and hygiene.

Nine-tenths of these girls can never obtain any education beyond the public schools. The few who can go to college can not afford to spend valuable time there in elementary and manual operations, neither can the college afford to spend its resources in doing what is more appropriately done in the elementary schools. But for the college girl there is possible a superior training for the higher duties of the home, which will be to her of far greater value than the average college curriculum, and which will have in it no whit less of disciplinary and cultural value. This training should range over the field of science, arts, and letters, bearing upon the physical, social, and moral problems and functions of the home, and should lead to a degree of equal significance with those granted in other scientific courses, as, for example, in engineering or agriculture.

It seems quite clear to me that the field of effort comprised in the term "home economics" is of such potential significance as to deserve recognition throughout the entire educational system, beginning with the primary school and ending with the university. As in the case of agriculture, the first steps of educational development in this field may most wisely be devoted to the elementary and manual training for young girls in the public schools. If public sentiment is not yet ripe for the introduction of these subjects into the public schools, it may, after all, be the wise course for the land-grant colleges—as leaders in molding popular views regarding technical and industrial education—to administer these primary courses temporarily, provided the public be made clearly to understand the reasons for so doing. Growing out of and in extension of these, there will follow in due time a legitimate course of study of collegiate character, in which cooking, sewing, laundering, etc., will have no place, but in which there will be thorough study of the natural sciences, with a generous allowance for the liberal arts, and for which the degree of bachelor of science may consistently be given.

Apparently such popular demand for instruction in household science as exists at present is chiefly for the elementary features, or at least for courses in which these have a considerable part. It is probable that strictly scientific and cultural courses, such as I have intimated should be required for a degree, will be but sparingly attended. Young women who attend college seem to prefer courses in liberal arts to those in science, and this attitude will continue until there is developed a popular knowledge of and appreciation for the art of doing things properly and well, and a pride and joy in work for its own sake. There must first come a general understanding of the value of this kind of education and a keener realization of its need before it will be popular with young women. This attitude of the public will best be developed by improving the elementary and manual training instruction in the public schools, since this reaches and influences the largest number of people, and yields the most tangible and the greatest results.

The land-grant colleges seem destined to have a large share in this development, and therefore have a large responsibility, which is not in the direction of aiding and encouraging this new education alone. They are in quite as great a degree responsible to the educational world for maintaining educational standards. A degree course in home economics will be entirely consistent with such standards if given for thorough work in the liberal arts and sciences as applied to domestic problems, but not if given for training in the manual operations of the household.

J. L. Snyder, of Michigan, presented the following paper:

WHAT OUGHT A DEGREE COURSE IN HOME ECONOMICS TO INCLUDE?

The true object of all education is to prepare for life. This preparation may bring the recipient into harmony with his environment, or it may develop in him sufficient power to create entirely new environments. It may be confined to the accumulation of knowledge, and the memory may be used as a case of pigeonholes, in which are stored selected data to be brought forth as occasion may demand, or it may be so directed as to develop power. Knowledge and power—the latter word used in a general sense—were at one time held as the chief and only objects of a higher education. In later years higher education has been called upon to perform another function, not only to give knowledge and power, but also such special training as will prepare the recipient for one particular field of labor. Education adapted to one particular end is commonly termed technical education. A degree course stands for a certain amount of culture and mental training. A technical course leading to a degree must in addition to the necessary technical subjects contain also such other subjects as will give a considerable degree of culture. Many technical subjects based upon previous training in science give mental discipline. This is specially true when pursued in the scientific spirit; other technical subjects train the hand and the eye, but afford little means for mental training.

A course in "home economics" is designed to give such training as will best fit the recipient for administering the duties of the home. These duties are many. To meet them intelligently a woman must not only be skilled in the selection and preparation of foods and clothing, but she must have all those other qualities of mind and soul which find their fullest fruition in her life as a companion, as a teacher, as a mother. Preparation for these duties requires much broader training than that usually given in technical courses. It is only recently that it has been thought advisable to give young women such training as would fit them specially for the vocation in life which the great majority of them are destined to follow and which the minority would no doubt gladly follow if they could enter upon such a vocation under circumstances satisfactory to themselves. While the progress of developing courses of study in home economics has been very rapid, such courses are still in the early stages of development. Yet considerable knowledge of a practical nature has been organized and worked out in pedagogical form and is given to a large body of young women with very satisfactory results.

The question, however, is, What ought a degree course in home economics to include?

First, it should be a four-year course and should be preceded by a thorough and strong preparatory course, not less in either quantity or quality than that required by all good colleges and universities for entrance to the freshman class of all degree courses. This preparation is fairly represented in the four-year courses given in our best secondary schools.

To correspond in a measure with other technical courses leading to a degree, about 20 per cent of the work of the freshman year should be purely technical; 33 per cent of the sophomore year, 40 per cent of the junior year, and at least 75 per cent of the senior year should be technical. This course should contain such studies as are of recognized exceptional worth for all courses. Higher algebra and solid geometry should be reviewed and electives offered in trigonometry, analytical geometry, and calculus. English should be given a very important place, and should include thorough courses in composition, rhetoric, voice culture, English and American literature, dramatic interpretation, orations, etc. Several courses should be offered in European history and political science. At least two years in a modern language should supplement that already taken in the preparatory course. A two-hour course in ethics should be given during the first term of the freshman year. This gives the dean or some other person of age and experience an opportunity to have heart-to-heart talks with the new young women concerning college ideals and other subjects such as young women away from home for the first time should receive light upon. Every young woman upon entering college should be given a careful physical examination and a system of gymnasium work prescribed, suited as far as possible to her individual needs. Physical training should extend throughout the course.

Music is certainly very desirable, if not really necessary, in the home. Hence, this course should offer at least two years of instruction on the piano, without extra charge, and also some opportunity for training in vocal music.

Drawing should be given a prominent place. Courses should be given in free-hand and charcoal work, to be followed by a short course in mechanical drawing, which would be given as preparatory to courses in woodwork and in landscape architecture. This work in drawing should be followed by a course in the graphic arts and also a course in the history of art. The backbone of the course, however, should be science and its application to household affairs. Physiology, hygiene, and anatomy should be thoroughly studied.

Botany should include courses in fruit and seeds, taxonomy, trees and shrubs, histology with elective courses in physiological botany, and advanced work in histology.

This study would prepare the student well for the work to follow in horticulture, landscape gardening, floriculture, and elective work in pomology, floriculture, and experimental work.

The course in elementary chemistry would be followed by courses in analytical, organic, and what might be termed in lieu of a better term, domestic science chemistry. The latter course would include the study of foods by quantitative methods, determination of the heat energy of various food materials, the sanitary analysis of water, etc.

Thorough courses in zoology should be given.

Instruction in physics, including laboratory work, should be given in sound, light, heat, and electricty, as well as some advanced work. Special emphasis should be given to ventilation and such other problems as relate to the home.

As bacteriology is a comparatively new department of science and one which is destined to play an important part in home economics, it might be profitable to consider briefly its value both as a disciplinary and as a practical subject.

The cultural side of bacteriology offers the following points: (1) It is soon learned from the study of bacteriology, that abstract mental deductions, founded upon the usual logical sequence, are by no means infallible, and, further, that what the human mind frequently suspects, based upon facts already at hand, may be diametrically opposite to what really exists; in other words, speculation and abstract reasoning are accepted in philosophy, but are ever prone to be erroneous in nature's studies. (2) The imagination is trained by bacteriological studies in following out natural processes instituted by invisible agents. Under such circumstances, what the imagination furnishes is checked eventually by the study of the real forces. (3) Accuracy is secured and delicacy of touch, through bacteriological laboratory manipulation. (4) A broader and more comprehensive view of life distribution is secured. (5) It becomes possible, through the study of micro-organisms, to gain an intimate knowledge of life structures and functions which can not be obtained by confining oneself to more complex life forms. (6) Many of the natural forces which have been mysterious to the student become real and significant by an acquaintance with the acts of micro-organisms.

From the utilitarian standpoint may be added:

(1) It is very desirable to know something of the contagious and infectious diseases, their propagation, dissemination, and control.

(2) It is highly desirable to be familiar with disinfection in all its phases.

(3) [illegible] acquaintance should be had of the antiseptic treatment of wounds, [illegible] of obstetrical practices.

(4) Every person should know something concerning food poisoning, due to toxins and ptomaines, and everyone interested in food should know something concerning its preservation in the form of canning, preserving, and drying.

(5) A knowledge of our water supplies and the relation to diseases should be understood.

(6) Likewise, sewage disposal should not be omitted.

(7) Home knowledge should consist, in part, of a familiarity with fermentations, as represented in milk, vinegar, and other substances, and putrefaction and decay should be thoroughly understood.

Many other topics commonly taught and practiced in bacteriology are of equal importance with the ones named. A course in bacteriology which should provide sufficient knowledge and training to equip students in home science requires at least one year of two hours each day given to the science. Of this, there should be two lectures each week, and eight hours of laboratory work every week throughout the year. Less time will not furnish necessary training to make the subject useful in everyday life, for its usefulness represents its greatest value, and scarcely a day passes in one's life in which one can not make use of it.

There should be given under the misnomer "domestic art," practical courses in all phases of needlework, beginning with sewing in its simplest form and leading to healthful and appropriate wearing apparel and to the decoration of the home. This would include plain sewing, dressmaking, hand sewing, art needlework, millinery, the study of textiles, and house decoration.

Women do not know how to keep house by instinct. Practical arts are learned by practice. This work, with the practical courses in cookery, would bear much the same relation to a course in home economics that shopwork bears to courses in mechanical engineering.

Under the head of "domestic science," which is another misnomer, should be given such instruction as would make the students familiar with the best and most economical methods of homemaking and housekeeping. The common facts of science should be correlated in their bearing upon household matters. The various methods of conducting a home in comfort and health should be discussed and the most important of these demonstrated practically. The course should include at least laboratory work in general cookery, cooking for the sick, waitress work, and advanced cookery.

Principles of cooking, with practical individual work, should include handling large and small quantities of materials. All elementary methods of cooking should be taken up and dealt with thoroughly—food value, cost, preparation, and cooking of vegetables, cereals, meats, etc. The lessons should be arranged in logical order and each principle illustrated by the preparation of simple dishes.

Lectures should be given on the various scientific principles which are necessary as a foundation for an intelligent understanding of the science of cookery. Then should be taken up the subject of foods, their composition, growth, history, preparation, and the manner in which they are affected by cooking, also a classification of foods, and the making of dietaries should be studied at some length.

This should be followed by a course in invalid cookery and also courses in advanced cookery.

Thorough instruction should be given in the serving of meals, care of rooms and furniture, cleansing agents, and laundry work.

The business side of home life should not be neglected. Instruction should be given as to business forms, simple cashbook as adapted to household accounts, notes, drafts, and other forms of commercial paper, monthly and yearly statement of expenses as compared with the ideal division of income as recommended by political scientists.

Courses should also be given in house architecture, emergencies and home nursing, sanitary science, and dietetics.

The amount of practical or technical instruction is limited only in time and teacher. The foregoing indicates in a rather indefinite way the amount and character of work recommended for a four-year college course at the present time. It is in fact the work offered in the women's course of the college with which the writer is connected. Courses in home economics are new and naturally very defective. They have been thrown together very often without much regard for the logical sequence of studies. Their nomenclature is little short of ridiculous, yet progress has been rapid and substantial, and in a very few years courses in home economics will be as clearly defined, as logically arranged, and as inspiring and helpful as technical courses in agriculture or engineering are at the present time.

The technical instruction will bear, in time and character, about the same relation to the culture studies of the course as the technical instruction of old and recognized technical courses bears to literary studies.

The question will naturally arise, Should such a course be crowned with the bachelor's degree? The answer to this question will depend somewhat on the spirit in which the work is pursued. If the object is simply to make a good cook or good housekeeper the propriety of granting a degree might be questioned. On the other hand, if all the work in literary language, history, science, and its application to the home is given in the spirit of investigation and the atmosphere of freedom the result in mental attainments and culture should be such as to lead to the bachelor's degree. Much of the technical work offered if properly taught will give mental training of no inferior quality. The cooking laboratory should be used as far as possible to illustrate and fix in the mind scientific principles.

The amount of mental training derived from any laboratory exercise depends very largely on the teacher. The work may be perfunctory and mechanical or it may be bristling with new problems, the proper solution of which will compel the student not only to recall past instruction, but to devise some original method by which to obtain desired results.

The course as outlined in charge of good teachers with proper laboratory facilities will give the students (1) mental development, (2) scholarly methods of work, (3) the scholar's working equipment, and (4) ability to meet with confidence and conquer the everyday problems of life.

To What Extent Should the Degrees in Land-Grant Colleges be Severely Technical and Scientific?

L. H. Bailey, of New York, spoke as follows on this subject:

It is certainly very difficult, after hearing so many papers touching upon this subject in so many ways, extending over a period of two days, to pick out any particular theme for discussion or comment. I think I have never listened to a series of papers which so fully cover the ground and which discuss the question so acceptably from two points, the theory of education and the actual practice in the different colleges with which these persons are engaged. Certain general considerations, however, have crystallized themselves in my mind as I have heard these discussions. If I were to make any particular statement the text for the remarks I am now to make, I think I would choose a certain sentence which was uttered by President Stone this afternoon—the statement that the industrial education, or the education of the land-grant colleges, had played sad havoc with the curricula. It may be well to ask, very briefly, why the work of the land-grant colleges has played sad havoc with the curricula. It is very evident from the discussions of the last two days that we have broken away from the idea of following exactly the text of the land-grant act—that is, we conceive the land-grant act to represent the purpose or intention of the education which it founded, rather than to set forth the method of instruction or the conduct of the institutions founded upon the grant.

Now, the land-grant education has not followed academic methods very closely, because the land-grant education was, and in fact now is, a revolt from the type of education which was then chiefly in existence. But there are specific reasons why the land-grant curricula have played havoc with the older courses. In the first place, the purpose of the land-grant idea of education is democratic rather than aristocratic. It is not conventional or traditional education. Its very purpose and idea is to reach all persons in the terms of their daily lives, and the terms of the daily life are very largely expressed, or were, at least, in 1862, in agricultural and mechanical arts.

In the second place, this industrial education reaches a new economic and social constituency. This constituency comprises persons who are not much given to assemblages and to organization, persons in whom the idea of individualism is very strongly developed (particularly on the agricultural side of the work of these institutions), persons, therefore, who do not go to college, but who have the desire to have the information brought to their doors.

In the third place, the necessity has been forced on the land-grant colleges of doing a great deal of secondary school work. They have been obliged to do much that is not college work, at least not in the old sense. We are gradually freeing ourselves from that necessity, as the common schools are teaching more science and more technical work and are fitting pupils better for entrance into real college work in agricultural and mechanical colleges.

In the fourth place, this whole land-grant college enterprise has been seized with the missionary spirit, it has been thoroughly democratized, and the effort is being made to carry it to the homes of the people by means of extension propaganda. Extension work is coming to be an important part of the work of the colleges, although it is not perhaps a part of the curriculum, but it has modified the character of the course work that is done in these institutions. I look upon the winter courses and short courses in agricultural colleges as purely extensional. I do not regard them as college work.

I lament the fact that it is so necessary for the agricultural colleges to hold short courses. It is necessary, however, because there are no other institutions in which that kind of work can be done. Speaking of our own case, I may say that we organized a winter course at Cornell University some ten years ago, supported by university funds. But there came a time when certain funds were given by the State for extension work. It seemed perfectly legitimate, as it was necessary, to maintain the winter courses on the extension fund, and they have been so maintained. The winter courses at our college of agriculture have no relation to the regular academic work of the college. At the present time they do have relation, so far as the teaching force is concerned, but if our plans hold we shall soon have a separate faculty for the extension work, including the winter course and some other extensional work.

I was very much impressed with the increasing confidence with which the different speakers dwelt upon the value of agricultural and mechanical education, showing that it has acquired a permanent place in the educational policies of the country.

There are several ways in which the general drift of this discussion possibly might be expressed. I note that all the speakers insist on the general pedagogical value of applied and technical subjects when these subjects are well taught. They regard these subjects as of equal training value with conventional subjects, provided the teaching is equally well done. On the other hand, there seemed to be a tendency to urge the introduction of many new subjects into the curriculum merely because they would find a place in the subsequent life of the person. I am somewhat inclined to challenge this point of view, for I conceive that the primary purpose of introducing any subject is its training and educative value and its power to put the pupil into sympathy with his environment. It may or it may not be worth while to introduce a subject merely because it is needed as a part of a livelihood.

Again, there is a marked tendency to react from the exclusively or specially technical undergraduate courses and to hold somewhat closer to some of the traditions of education. I think that the general tenor of these discussions enforces this remark. We are now considering a middle course, it seems to me, between the exclusively professional work of these colleges and the traditional or conventional education. If we can not teach everything, neither can we afford to break with experience, and the question is how much of the new we shall combine with something of the old. Through the papers there seems to run a sentiment that training for mere manual skill should be eliminated from courses that lead to degrees. This you will recall is very forcibly expressed in the change of attitude in the agricultural colleges during the last twenty years in respect to compulsory manual labor. All of them have now given it up, and the labor now required in the agricultural colleges is on an educational basis, namely, laboratory work. The growing disposition to occupy the first two years of a college course with fundamental, or what some people wish to call "pure science" subjects, is a further indication that mere technical training is insufficient.

I was much interested in the chart presented yesterday by Professor Rane, in which he tried to put back the fundamental courses in the first two years of the agricultural course. I fully sympathize with that idea, and I think all the speakers have given suggestions along the same line. It may be worth while to speak of the disposition of the horticultural courses at Cornell University, inasmuch as they were mentioned by Professor Rane. You will recall that certain institutions were compared with respect to the horticultural courses. Every one of these institutions except Cornell University requires horticulture as part of the four-year course. I have had something to do with horticulture at Cornell in the past years. There was a regulation at one time that all students graduating in the college of agriculture should have had a certain amount of horticulture. At my instance that obligation was removed.

I felt that the first two years of the course should be given to fundamental courses, and that in the third and fourth years a man might have the privilege of specializing in dairy work or horticultural work, as the case might be. I did not agree with Professor Rane's idea that some technical horticulture and dairying should be required in the early course and that a man graduated in that course should be well fitted for taking up one or more of these professions if the necessity should arise. I would rather think that he should be exceedingly well prepared to take up one occupation. I am not quite sure whether in the future we shall have departments of horticulture. I rather think that we shall not; that is, on the lines on which they are now organized. Horticulture as now outlined in the institutions of the country is very largely an occupational subject rather than a pedagogical subject. I would like to see all colleges require, for example, a course in plant propagation, which should be in some way related to botany. I think that the fundamental plant-growing subjects should be a part of the botanical or similar courses in the early part of a four-year course of instruction.

The drift of opinion seems to show that there is a general harmonizing of the conduct of the courses of instruction in all the land-grant institutions, and a determination, even in the midst of the many new subjects which are clamoring for admission, to teach what are really the fundamentals. I think the tendency in our land-grant colleges, as also in the secondary schools, is going to be to simplify rather than to add more.

Again, there is an increasing sympathy with the workaday life. There is an increased desire, nevertheless, to introduce other subjects that have relation to the everyday lives of the people, but they can be so treated as not to conflict with the other subjects, but rather to aid and complement them. It seems to me that these discussions indicate that the land-grant colleges are becoming a concrete expression of democratic ideas.

The home-making subjects are dwelt on in some of the papers. The reason for these courses is not the specific occupations for women; the home is the center and the reason. The various speakers have mentioned the difficulty of securing a name for a course covering these subjects. I have challenged them all. Temporarily I use the words "home economics" as perhaps broader than most others and having less objectional connotations. I like to think of the course of home economics as comprising more than housekeeping subjects, larger than "domestic science," as that term is commonly used. We have been trying to increase the productivity of the land; we have not emphasized the value of the home as an entity. It is time that we emphasize the home, study it in relation to the community, to the school, to the church, to organization, and to all the large economic features which have to do with the relation of the home to the general welfare.

The general drift of this discussion shows that the land-grant colleges, particularly on the agricultural side, do not regard the courses as professional or at least not as severely technical. And if that is true, I think it means a very great gain for agricultural education. This education is industrial in a broad sense. It is natural education, and is founded on general pedagogical principles and methods. I am coming to like the phrase "education for country life" instead of "agricultural education." The idea no longer stands for technical agricultural instruction alone. It stands also for all the social and economic relations of the farm to its community. It stands for the discussion of the rural church, the rural school, rural literature, sanitation, good houses, good roads, organization, and all the laws that govern trade in farm products. So I like to think that the agricultural college now stands for the open country in its largest and broadest sense. Possibly we feel this more forcibly in the East from the fact that the cities are so exceedingly important in our old Commonwealths. For example, in New York State there are 8,000,000 persons, about 1,000,000 of whom are on the farms. Therefore the character of instruction which we are called upon to give may be somewhat different from that which colleges in the corn-belt States find to be best, where perhaps half of the persons are on the land or directly connected with it.

I was very much impressed with the fact that the papers emphasize the pedagogical ideas more than they would have done a few years ago. This means, of course, that we are looking on the courses of agriculture and mechanic arts as courses having training capabilities as well as fitting for a distinct occupation in life.

There is another feature of the work at the agricultural colleges which has not been mentioned. It is spirit. I can conceive of an institution with no agriculture in its curriculum which still teaches good agriculture; and, conversely, ever so good a curriculum will not make an agricultural college. Good spirit is half of a college course. Perhaps it would be better to say that no college course is worth the while without this enthusiasm and fullheartedness. I would think any agricultural college quite remiss if it did not somewhere and at some time take upon itself the responsibility of calling its students together for the purpose of general intercourse or general reading, or for lectures and discussions of large questions which are not directly agricultural. I like to think of the agricultural student as a man who has the roots of his affection founded in the traditions and experiences of the human race as expressed in literature as well as in the distinct industrial vocations in which he is engaged. A great deal can be done in training men's minds and directing them wholly outside of any curriculum which may be put on paper. I am sure that every one of us feels that there are possibilities in the administration of a college of agriculture for educational uplift and spiritual enthusiasm wholly outside of the curriculum in the college catalogue.

Hon. William T. Harris, U. S. Commissioner of Education, being introduced, spoke as follows:

ADDRESS OF HON. WILLIAM T. HARRIS, UNITED STATES COMMISSIONER OF EDUCATION.

Mr. Chairman and gentlemen, I had the honor to make some remarks this morning in the general session relating to the vestibule of education, meaning by that the preparatory studies which furnish a common basis for higher education, and especially for that part of the higher education which specializes its studies. I will confine my remarks now to the relation which the specialized subjects in agricultural and mechanical training have to the common preparatory branches which belong to the vestibule of the temple of learning. We have a law of Congress which provides an endowment for the agricultural and mechanical colleges of $25,000 each, and which provides specifically that the benefits of said annual endowment shall be applied only to instruction in agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural, and economic science, and to the facilities for such instruction. The omissions in this list are very important and suggestive. One will notice an absence of branches relating to other languages than English, and especially to the omission of the so-called classics, Latin and Greek. It had happened before in the State institutions which arose on the foundation of the endowment of 1862 for the establishment of colleges for the benefit of agriculture and mechanic arts that older institutions, modeled on the basis of the college or university for general culture, had obtained the advantages of said endowment, and not being limited in their application of the fund had used it for the most part in strengthening what I have called the vestibule to education—the general preparation for higher studies. Inasmuch as the students seeking general culture were far more numerous than those who had marked out for themselves careers in special industrial studies, it had come to pass that nearly all of the benefits of the agricultural and mechanical endowment had been applied to the branches which underlie common culture, namely, foreign languages and especially the so-called "dead languages," Latin and Greek, and to modern languages. The new endowment of August, 1890, therefore, provided in a careful manner that its proceeds should not go toward strengthening the foundations of education, but should be applied entirely to the superstructure of the special education intended for agriculture and mechanic arts.

It should be said at this point that application of the earlier endowment, that of 1862, in such lines as had already been fixed in the older college education was necessary, partly because there had as yet not been formulated, or at least not yet published, any systematic and well-graded course of instruction in agriculture or the mechanic arts. There being comparatively little experience in this field and only feeble attempts to reduce it to a course of study, the directors of higher institutions found themselves in the presence of a formidable difficulty in carrying out the obvious intentions of the first endowment, that of 1862. In the meantime nearly thirty years of experiments in collecting and systematizing a body of doctrine relating to agriculture, as it is found in the United States and elsewhere, had elapsed. The time had arrived, therefore, in 1890, when a new endowment could be guarded in its applications and directed toward the specialties of agriculture and the mechanic arts, and its application to instruction in ancient and modern languages entirely prevented. Nothing of this new endowment should go to the traditional foundation studies, to higher education, with the exception of mathematics. The history of the application of the first endowment, that of 1862, had shown conclusively that no superstructure would arise on those foundation studies, and that the endowment for agriculture and the mechanic arts would only go so far as to furnish a vestibule to all kinds of higher education, and especially to education for the learned professions.

Of course all these things could not have happened unless suggested or at least permitted by current public opinion. Nine out of ten persons desired a general foundation for higher education instead of instruction in specialites relating to agriculture and the mechanic arts. There had been very few examples of learned men in those specialties in this country to attract young men into agricultural and engineering careers.

In the history of the United States since 1862 one of the noteworthy lines of progress relates to mining, another one to railroad building, another one to the manifold uses of electricity, and still another to the progress in organic chemistry and the application of inorganic chemistry to various other industries. It has been an era of the unfolding of engineering in manifold directions for the conquest of matter and force in the service of man.

In the meantime free public high schools have been founded, mostly at the expense of municipalities, all over the United States, and the elementary beginnings which belong especially to what I have called the vestibule of education have been provided abundantly. But opportunities for pursuing long courses of study in special branches of industry have not been furnished so generously for the youth who have completed their preparatory studies and who have adopted for themselves careers which demand long periods of original investigation, under distinguished experts, with access to well-equipped laboratories.

Meanwhile the agricultural and mechanical college as it has been has slowly built up a body of doctrine in its specialty and has obtained a sufficient survey of its course to outline for itself without any serious error the course of future progress in enlarging the scope of its instruction and in perfecting its methods of investigation.

Many agricultural colleges are represented here in this audience by professors who have done distinguished work in reducing various branches of their work to a better pedagogical form. A branch is reduced to a pedagogical form when it can be taught in a series of lessons, of which the first lesson is useful if none follow, and the first two, or first five, or first ten develop each lesson out of the next preceding one, partly unfolding the consequences of what precedes and partly explaining the grounds of what precedes. Good pedagogical form makes possible systematic instruction in the school.

My thoughts have lately been directed toward the relation in which the advanced specialized higher studies stand to the body of preparatory branches. In what way are those early studies in the high schools and in the freshman classes of colleges and universities related to progress in the mastery of science and to the original investigations which advance science itself and make possible its applications to industry. I will limit myself especially to the old question which has so many times been thrashed out regarding the use of certain kinds of language study as an essential preparation for the several sciences of nature.

The interesting and suggestive course of study in horticulture, which is mapped out and exhibited on the walls of this room, furnishes me a text. I notice the words "agronomy, zootechny, agrotechny, rural economy, rural engineering, apiculture, viticulture, pomology, olericulture, floriculture, horticulture, botany, zoology, meteorology, mathematics, geology, physiography, biology, bacteriology, entomology, veterinary science, agrostology, embryology, cryptogamic botany, vegetable cytology." This course of study before us and the courses of study published in the catalogues of the institutions founded on these two endowments of Congress go to prove that Latin and Greek are not dead languages, as they were supposed to be, but are languages that are quite alive in science and the arts. Even in agriculture the sciences have borrowed words both from the Latin and from the Greek in order to arrive at a perfect accuracy of expression. Colloquial words of Anglo-Saxon roots are well enough to express ordinary experience, but not at all adapted to the expression of the results of precise and systematic investigation. There are two vocabularies in a language—the colloquial vocabulary and the vocabulary for science, literature, and philosophy. Everybody uses the colloquial vocabulary in common, but only those who are specially educated in the branches of a higher education can use intelligently the second vocabulary. Ordinary colloquial discourse is well enough in its way, but it is only a beginning of language. Its objects are simple and undefined and on the whole shallow as to thought. The word "knowledge," for instance, expresses in one word all sorts of information and reflection. It is a great, undifferentiated heap of results of acts of knowing, while science—expressed by the Latin word scientia—expresses a systematic organization of facts in such a way that each fact throws light on all the others. Knowledge is for the most part a heap of isolated, undigested particulars of perception and reflection, mere shallow facts mixed with more or less profound observations of all kinds. Science, in the first place, classifies its facts and brings together those which throw light on one another into one branch of science. Then it connects these systematically, so as to show their order of genesis from the first to the last. The difference between a dumping heap, where all sorts of things that are of no use are piled in confusion, and a regular and symmetrical piece of architecture is something like the difference between knowledge and science.

This is preliminary to the answer of the question, What kind of language study aids in the mastery of natural science? One can not help thinking as he looks over the names of the divisions in the scientific course of agriculture, or in mathematics, or physics and chemistry, or geology and geography that the pupil's time must be taken up, in the higher special courses of study, in memorizing technical words of many syllables, unless the pupil has in his earlier preparation made the elements of those words significant. If the student has learned Greek in his preparatory years, the word "agronomy" divides out for him at first sight into the roots of the word "agros," a field, and the word "nomos," signifying a usage or a principle of management; "agriculture" suggests the Latin word "ager," a field, and "cultus," from "colere," to sow or plant. A knowledge of the meaning of the parts of a word is a powerful aid to the understanding of the meaning of the whole word and to the retaining of the same in the memory. Thousands and thousands of technical terms occur in botany, all founded more or less on Latin words. A superficial study of Latin will increase the power of comprehending the scientific technique of botany. As long as one does not know the language from which the technical terms are derived, he is forced to make a greater effort to remember them and a greater effort of mere mechanical memory without thought. Compare the difference to the ordinary college-educated man between a term derived from the Sanskrit and a term derived from Latin: "Magnanimous" can easily be understood by the Latin student on recalling the word "magnus," great, and "animus," the soul or mind; the word used in the Bhagavad Gita, "mahatma," frequently used by students of the so-called esoteric Buddhism, is difficult to remember unless one has the same elementary knowledge of Sanskrit, in which case he recognizes the first part "maha" as meaning great and equivalent to "magnus," and "atma," the soul; or take maharshi, which is "maha," great, and "rishi," a sage or wise man. Take also the geographical name of the country at the mouth of the Indus River in India; the territory is called Punjab. The person superficially acquainted with Sanskrit recognizes the first part of the word, "punj," as meaning five, and "ab" as meaning river. The Punjab is the delta land between the five rivers or branches of the Indus at its mouth. An elementary knowledge of Latin and Greek gives one the power of retaining and of comprehending technical terms with a fine sense as to the shades of meaning. It is a matter of every-day experience to see students not acquainted with Latin make a mistake in spelling or in identifying the parts of a long technical word, and, what is worse, a mistake in getting hold of the shade of meaning indicated.

This brings us to the insight that Latin and Greek are very far from being "dead languages." No longer used colloquially for simple conversational speech, they are all the more used for preserving the results of scientific observation and for literary expression of fine shades of feeling and distinctions of thought, and it is very necessary to get the elementary significations of the Latin and Greek roots, which one does in his three years' high school study of Latin, in order to acquire a fine sense of the use of these words in scientific technique. It also makes the technical vocabulary as easy to remember as the colloquial vocabulary. The word "carnivorous," for instance, has the root "carn" and the root "vor," "carnis" meaning flesh and the root "vor" to eat or devour, the whole word meaning flesh eating. The lack of a feeling of the original meaning of these words produces the ludicrous use of language caricatured by Shillaber in his "Sayings of Mrs. Partington." Mrs. Partington is a type of the person who has no adequate sense of the original meaning of the classical derivatives which he uses. Uneducated colored people often furnish examples of speech of this kind. One of them, for instance, goes to a drug store and asks for a "nanny goat" for a particular poison, meaning "antidote." And Mrs. Partington thought that "total depravity was a very good doctrine if you could only live up to it." The Greek meaning of the word "antidote" is just as easy to remember as the name of the domestic animal to a person with a smattering of Greek, and the Latin meanings of "total" and "depravity" are equally easy to the one who has given some study to Latin.

The fact that what is called a complete English dictionary contains three Latin or Greek derivatives to one word from a Gothic source shows us that to the educated man the livest part of his language, so far as science and literature and the higher order of thoughts are concerned, is the Latin and Greek contingent. Any person who had to learn botany or chemistry would find it worth his while to begin by a three years' study of Latin and Greek just for the benefit of these languages in his scientific education. So, too, for history or for poetry, and by far more essential for medicine, the law, and divinity.

I admit that there is abuse of time and energy in studying Latin according to the favorite methods pursued in preparatory schools and colleges. I had a poet friend, a chum of mine at Phillips Academy, Andover, in the times of Samuel H. Taylor, the Greek scholar. Meeting him at a reunion of our class after many years, I asked him, "What did you learn at Andover, and what did our class learn?" He replied, "We learned the exceptions. To be sure, we learned the paradigms; but that did not take much of our time." It was the committing to memory of lists of unfamiliar words which were said to be exceptions to the regular declensions and conjugations. The memorizing of these exceptions, however, is not a serious matter as compared with the time spent in classical schools in learning the quantities of vowels in Latin words. In the English universities, Oxford and Cambridge, and at the English preparatory schools they learn not only the laws for quantity, but they learn the numerous exceptions and the innumerable cases of vowels which are long or short only "by usage." They learn these with such painstaking as would be required to make Latin poets, and they test the quality of their scholarship by actually requiring written verses in Latin. This is all the more astonishing because no person knows precisely how the quantity of Latin vowels affected their pronunciation. There may be some shrewd guesses on this point, but there is little real knowledge on it and no complete theory.

One is led to suppose that the English gentleman desires to celebrate his contempt for what is useful not only in the line of bread and butter studies, but even in the line of producing science and literature. He studies the quantities of Latin vowels to show his contempt for utilities either in the conquest of nature or in the combination of men into social wholes for business or politics. I admit that in some cases, especially in the case of Tennyson and Milton, the study of Latin quantities may possibly have quickened the ear to the melodies possible in the English tongue, and that we owe in the case of Tennyson and Milton much to their work in the preparatory school in the way of learning quantities. But if "Shakespeare had little Latin and less Greek," he certainly excelled both Tennyson and Milton in his discovery of the capacity of his native tongue for a greater compass of music than the classic tongues ever possessed. However this may be, I for one am glad that American preparatory schools, especially in the public high schools, waste very little time in the learning of Latin quantities. For those who claim conservatism in this matter and insist with great stress on the study of quantity as the real key to the benefits of Latin and Greek there is very little defense, since the studies of comparative phonology and other branches of classical philology reached their height in the last generation.

It remains true and will remain true that in the English language Latin and Greek must be studied because they are still living languages and not dead languages, because they are the living languages not of the colloquial vocabulary of common sensuous experience, but of the scientific vocabulary not only of the strict sciences like mathematics and logic and physics, but of the experimental and historical sciences one and all, and because the characteristic vocabularies and styles of the great literary writers of English are to be identified through the possession which they show of fine shades of meaning and the newly attained powers of expression of moods of the soul, their refinements of taste, lofty aspirations, and subtle thoughts, all made possible by skill in using the

Latin and Greek derivatives, which reenforce the Anglo-Saxon vocabulary by a wealth of words three times as great as that derived from the old English.

W. O. Thompson, of Ohio, presented the following paper:

DISCIPLINE—STUDENT CONTROL.

The question of college discipline has been debated rather vigorously for thirty years. The changing conditions within the colleges, as well as the changing conditions in civic life, have made it certain that the college must meet these new conditions. Some changes in discipline and in methods of student control were manifestly imperative. Just what these changes should be was from time to time the vexed question. No one now doubts the wisdom of certain changes, nor is there any disposition, if there were the ability, to return to the former days.

First of all, there was in the earlier college a prescribed course of study, usually a dormitory system, an isolated location, where contact with very much of the world and its activities was difficult, and oftentimes a preparatory school, which admitted boys in the early teens whose parents asked for or expected a supervision of practically all the boy's habits. This last item was much emphasized in the minds of both the college and the patron. The college was expected to turn out high-minded men, of religious conviction and of moral worth. This confessedly high ideal was proclaimed not only as possible, but as one of the constant aims of the college. The result was that many people believed in the college, not so much for any intellectual results, nor for any culture it secured, nor for any efficiency it produced in the student, nor for any definite scholarship, as for the social, moral, spiritual, and religious development. People came to believe that the college was a good place to send almost any boy because of these results. Accordingly the questions of discipline and student control were always important. The college must meet these in a satisfactory way or face the danger of losing its hold upon popular favor. Under this order of things there grew up certain customs, beliefs, and ideals that have continued to this day in the minds of many people. Students housed in dormitories and kept under the constant supervision of tutors, preceptors, and other officials, who were guardians of both morals and daily habits, came to believe that college pranks and student disorder were part of college life. They saw no inconsistency between the most fervid religious profession and the meanest of college pranks. There grew up the belief that students should not be expected to conform to the ordinary laws of conduct. The law of the land was intended for citizens, but not for students. They were still under some sort of a family government with which the State should not interfere. The old tradition of the town and the gown is a remnant of this college insanity. No student had any civic responsibility, and therefore no civic morality. Most of us have heard protests against discipline when college authorities held students to anything like the common standards among citizens. Nearly every college in the land, especially among the older ones, has suffered damage to or destruction of college property at the hands of students in obedience to traditions handed down from year to year. Moreover, these things were accepted as a matter of course by students, faculties, and the community. It has taken us long, weary years to grow out of these traditions and to secure practically unanimous consent to the truth that students should be held to a strict account for conduct and should be held by the same ideals as the ordinary citizen. The development of the public school did much to change our thinking and our standards. No board of education would trifle with pupils destroying or mutilating property as the college authorities have done. Accordingly we have developed a group of boys and girls in our public schools that are a little more sane on questions of civic morality than the old-fashioned student. When all our colleges abandon their preparatory schools the problems of discipline will be cleared up and the standard of student life elevated.

The State universities have also made a distinct contribution to the results now enjoyed. As a rule these institutions regarded themselves as a part of the public facilities for education in an important sense, bound to pay respect to the public schools in the several Commonwealths. In the main they were without dormitories. The demand for the type of education provided at these institutions was so great that legislatures were kept busy in appropriating money for education rather than for a means of living. Being without dormitories in the main it became necessary for these universities to emphasize to their students that they were there at public expense and would be expected to conduct themselves as citizens should. Nearly all these universities abolished the preparatory school and therefore had an older grade of students than could be found in colleges having preparatory departments. Responsibility was therefore insisted upon from the start and students were brought to see that they were dealing with the State. Few of the traditions common in the earlier colleges ever fastened themselves upon the college life of students in State universities. The rapid growth of these institutions brought the public to see a large body of students free from traditions, representing practical democracy, and face to face with the problems of self-control.

The elective system sometimes attributed to Harvard, but really born at the University of Michigan, had much to do with changing the problems of college discipline. As soon as students were found at college confronted with the fact that the responsibility of their education was a personal problem they became serious. The elective system puts upon the college the responsibility of being genuine when it offers a course of study. It must have back of the announcement something that commends itself to the attention of students and that will command their respect if it is taken. The college can not evade and avoid responsibility by saying it is teaching an unfortunate text-book; the modern college offers *subjects*, not books, for study. It must be prepared to justify its announcement by a masterful treatment. In a similar way the elective system puts upon the student the responsibility of doing the right thing in his education. I am aware that many people sneered at children making choices and determining careers; nevertheless the modern college has insisted that students shall choose. What are the results? We find now that the questions of course of study and of career are debated at home and in public high school. A few students still come to college because they are sent, but most of them come because they want a larger opportunity. They are taking the college and university seriously. They are taking themselves seriously. The faculties have learned that such students require less discipline and more leadership. It has made the modern professor wake up to his opportunity and his responsibility. The college has also seen that it can not preach religion and talk upon the high ideals of spiritual culture and not be honest in its curriculum. This strong insistence upon a somewhat rigid morality has put a vigorous tone into all our colleges. Wherever troublesome questions remain we shall meet them best by emphasizing the duty of high-grade action in our colleges. Even football seems likely to surrender to the demands of the class room. Certainly nothing will more stimulate its ethics. Furthermore, it is worth while to call attention to the beneficent results that have come from the development of industrial education. The presence of manual training in the elementary and high schools has greatly improved the spirit there. In the colleges of agriculture and mechanic arts, and in all institutions where technical and industrial education of any sort has been introduced, there has been less of troublesome discipline than in the older colleges. When industry becomes a virtue idleness will become a vice. The student, consciously pursuing a course of study that leads somewhere, becomes enamored of his journey. The whole problem of discipline lies in the problem of securing on the part of the student a conscious pursuit of a desired end. All forms of industrial education put emphasis upon this. No student can successfully pursue a technical course such as the institutions in this association offer without some choice made in view of a definite purpose. At present the constant debate between the student and the college is as to the content of the course. The student thinks there is too much irrelevant matter in the course and the institutions attempt to justify these subjects by reasoning that the student does not appreciate. The subjects, he thinks, are too remote from his purpose. I am not now justifying either faculty or student; I only call attention to the fact with the added remark that the condition is pretty conclusive proof that the course is not in its final form and never can be. My desire is to call attention to the truth as I see it—that this attitude, this seriousness of purpose, has solved many of our most difficult problems in discipline and will solve more of them as we give it opportunity. In the older days the problem was to get the student to do what was ordered. In the modern days the problem is to get the college to do what ought to be done. Students are now less of a problem than faculties are. In proof of this witness the discussions in faculty meetings, a few echoes of which have been permitted to slip into public print under assumed names. Moreover, the discussions for the last two decades illustrated the same thing. Passing now these general principles on discipline and control, let us look briefly at the general plans that have been adopted as a working policy. These fall into three classes, namely, faculty control, student government, and administrative government.

I.—THE METHOD OF FACULTY CONTROL.

This was the earliest form and assumed that the teacher and the faculty were in *loco parentis*. The school assumed the family relation and family responsibility. The student, as the boy in the family, often became conscious of his growing powers and felt the right to assume responsibility. When this was practically denied by the form of the government a spirit of rebellion often developed. He regarded himself as an irresponsible creature. He never was quite clear that the paternal idea was well founded. He assumed that the faculty was against him and therefore he was against the faculty. The pleasing exception to this condition was found occasionally in some professor who was an inspiring leader and who was so beloved that in his classes discipline was invisible. The paternal idea brought many a boy to regard his teacher as a driver. The ideal is that he should be a leader. Further, under this system rules were the logical consequence. The faculty could not always be in bodily presence, but they could send a rule as representing them. Then, too, faculties adopted rules by a majority vote and it was not always clear that every rule or law had a sufficient sanction back of it. Indeed I think it fair to say that this system with its disregard for law was demoralizing. Mature men now laugh and alumni come back to the old college and hold up to laughter, if not to ridicule, many of the customs and laws under which they lived as students. The narrowing effects of much of this government can not be denied. We have come to see in these days that it is a mistake to overlook the dawning of maturity that is in the college student. He recognizes it and faculties ought to. The family expected the college to do much that is now done before the students start to college. In the modern life our boys have pretty well formed and stable habits before their college matriculation. This is not so much a matter of years as it is of experience. Many of the results sought after in the college are now secured in freshmen. Less freedom in college than the boy has had in high school will not be welcome to either parent or child. We are bound therefore to move away from the older methods. When this movement came it was impossible to return to the old order of things. Some other method was a necessity.

II.—STUDENT GOVERNMENT.

Naturally perhaps the college world turned to the method of student government. This was the other extreme and like all extremes attracted many people but was regarded with some doubt by the conservative. At the University of Illinois about 1869—then the Illinois Industrial University—an experiment on a large and elaborate scale was attempted. This really was a miniature republic with officers duly elected and charged with duties to which the students had assented under student legislation. That experiment was abandoned after a trial. A crisis came which tested authority which proved fatal to the whole plan. A full account of this interesting experiment may be found in the proceedings of the National Educational Association in an address by President Selim H. Peabody (see National Educational Association proceedings 1889, page 539.) Another notable experiment was with President Seeley at Amherst. Here a strong, forceful, and pleasing personality won the students to him and his methods. For a time student government flourished, but here as so often in political affairs the death of the ruler left a dismembered government. At Amherst there has been no successor to President Seeley in this particular. When we examine into the causes of the decline of student government we discover that it grants authority but can not fix and locate responsibility. At any moment a student may withdraw from college and leave nothing behind but a record of suspension or dismissal. This in no way compensates for the lease of authority. The college can not run away; it must remain as the residuary legatee of all the mistakes or blunders of the departed authority. Moreover the force of law lies in its penalties. A student court or legislature will neither decide nor legislate against students in a disinterested way. Faculties even will not criticise each other. They are very slow to discipline their fellow members. What then can we expect of students whose personal attachments are often closer and more biased.

In addition to these considerations, the State, through its courts, will not recognize the legal standing of a body of students. The responsibility for property, for the use of funds, and for the general welfare of the college is vested in trustees and faculties. Student authority is therefore, at best, delegated authority, with a strong reason to doubt whether the constituted authorities have any right to delegate to students. The whole situation lacks genuineness. The student is a temporary resident for a specific purpose, which is not government, but instruction. He is there voluntarily, with no definite or assured tenure of position. It seems irrational, therefore, that he should take into his hands the temporary administration of policies and interests of which he is neither the creator, the supporter, nor the guardian, but wholly the beneficiary.

This is not to say that a student or a body of students should not be consulted; it may be the highest wisdom to advise with such bodies. It is important that all available facts be known; that there be a clear understanding of all conditions and problems; but I object to the policy of fooling or trying to fool a student by leading him to think he is governing the college, where, as a matter of fact, the college is governing him if it is doing its duty and administering its trust.

III.—ADMINISTRATIVE GOVERNMENT.

The third method may be described as administrative government. This is the method steadily coming into use in all our colleges. Under this conception there are some things to be assumed—among them (1) that the college is a public opportunity, (2) that the property is a public trust, and (3) that the faculty is an organized agency for cooperation and leadership and the student a responsible party whose privileges are to be measured by his willingness and ability to make profitable use of the opportunities.

These conceptions banish at once from the minds of all the old notion of antagonism between student and professor, and put the college life on a natural and rational basis. The faculty is therefore naturally and properly the legislative body, and the president and other officers—such as deans in our larger schools—are the administrative officers. The whole government becomes one of principle. The modern college steadily approaches the spirit of democracy, where all students stand on a level of equal rights, with no favors. As soon as students come to understand this situation the sobering effect of responsibility is manifest. There can be no trifling with principle; hence the offenses against good government are serious. This view holds out that a student is not in college as an accommodation to the faculty or to the public; the faculty and the institution are there for his accommodation if he will use it properly. Colleges are steadily going out of the nursing business. Students must go elsewhere for their health or the indulgence of their whims. The college is for business, and a very serious and important business at that. The details of a student's life are important to the college chiefly because they help or hinder the great cause for which the college stands. I believe we have often weakened the cause of education by leaving the impression that discipline is an important issue. The truth is, it is only an incident. If the student can not understand this, he should be given to see that his preparation for college life is yet incomplete and that he ought to go elsewhere and complete his preparation. I believe thoroughly in a large and liberal spirit which locates responsibility, and in a system of government that has the courage and firmness to promptly say to students that their privileges as students cease when they fail to be good citizens.

The best test of a student's right to be in college is his satisfactory performance of the student's duty. The academic requirements should be insisted upon firmly and even rigidly. Insist upon it that education—the requirements of the curriculum—shall be promptly and regularly met. This attitude neither accepts nor makes apologies. The average student will soon see the force of this law and the justice of it. If he is not fit for such a school he will soon drift to his proper circle; but he will do it with increasing respect for the institution of which he was not worthy. That in itself is a valuable result to reach.

I believe, therefore, that the whole question of college citizenship should be defined by a few fundamental and important principles. These should be public. The student should be face to face with the law of the college, just as the citizen is face to face with the law of his land. These laws are made by properly constituted authorities and administered by properly constituted officers. In State institutions the force and power of the State is behind college administration. This fact should be clearly and persistently set forth. In a State institution or in such institutions as are represented in this association the supremacy of the law of the land and the necessity of good citizenship should be as clear as the day. College authorities should turn over to the State authorities every offender. It may appear rigid and cold in the first instance or two, but there will be a long interval between troubles. In my own experience I have not hesitated to declare that the law of the State would be enforced and that I should regard any destruction of property or interference with the rights of citizens or students as proof of a kind of citizenship that could not be endured in a college. I believe that American students respect an administration that respects itself and respects the law of the land. In a college, as elsewhere, the cure for disorder is a high order of citizenship. Let the high ideals of a genuine democracy inspire the colleges and we shall hear less of hazing, of dishonorable college traditions, but more of scholarship, of college fellowship, and of social service.

G. E. FELLOWS, of Maine. It appears to me that the student has three relationships in the university or college. One is toward the educational administration, whatever has to do with its class of work, his examinations, and his degrees; another relation is with his fellow-students and with the faculty as social members of the community, and the third is with the community at large—the public.

It should not be the part of the student in any way to dictate the terms in which he is related to the educational features of the institutions. Those are already provided for by statute or by the organization of the institution. As to relation to his fellows, there is no reason in my mind why there should be formal rules. I think most of us have come to believe that.

In the relation of the student to the citizen and public in general there is a growing desire to throw the whole responsibility on the civil authorities. I believe myself that that is the only way to deal with all such questions. I think the college authorities should not deal with them, but that they should be dealt with entirely by the civil authorities, and the sooner they are taken up by the civil authorities the better. I believe all sorts of offenses which in any way constitute civil offenses should not be ignored, but should be taken notice of as any other good citizen takes notice of them, but not in any way taken up by the college authorities for the purpose of college discipline. I leave purposely the relation of the students with each other and with the faculty in a social way to them, and after an experiment for two years it seems to be extremely successful in solving the difficulties that have arisen in that way. We do not give up our authority as regards offenses, if there be offenses against the educational orders and discipline of the institution. And we have disposed of the civil affairs as I have already told you. But with relation to the student affairs we have established a council called the university council, composed of three seniors and two juniors and four members of the faculty. The faculty members are elected by the faculty, and the two juniors who are elected serve through both their junior and senior years, and thus there are always two experienced student members of the council. At the beginning of the senior year the seniors elect a third member and the juniors elect their two new members. All affairs that seem to need attention, not necessarily of discipline, for the upbuilding of the institution or the furthering of student interest or the general furthering of university interests in the public, and with the State or the consideration of matters which really need attention in the way of discipline, but are not strictly related to the educational affairs of the institution, are dealt with by this council. In several instances the council itself—that is, the student portion of the council—has brought up to the whole council matters which needed correction in the student body. I do not think that the general body of students feels in any way that it is watched by the council, or that the council preaches too much. It does not often preach. The college meeting is called and the faculty are excused, and some member or members of the student council make little speeches on matters of general interest, the care of college property, the appearance of students in public or in neighboring towns, or in the matter of social entertainments, in such a way that we have been almost entirely relieved for the last four years of any kind of difficulties arising between the classes or between the fraternities or between students and faculty. I can not say that our system would satisfy any other institution. I do not know that it would. But as far as possible I have tried to keep the three relationships of the student separate, and I hope that time will establish customs which seem to be growing, so that we shall be free from the real difficulties of discipline.

J. C. Hardy, of Mississippi. The first thing that I think we ought to get before the student body is the correct view of the whole relationship—what the college is for. We make it very clear to our student body that the college is for them, provided they behave themselves and take advantage of it; that the faculty, president, equipment, and everything exists for the student, and that therefore any requirement that is made is not for the benefit of the president or for the benefit of the faculty or of the college authorities, but for the benefit of the student body, and that the college does not need him, but he needs the college; that the college was established by the legislature of the State for the purpose of giving opportunities to the young men of coming there and equipping themselves for life, and that the college has all the students it cares to have unless the student wants to come and take advantage and get the benefit of the work that the college is doing. I consider that the correct point of view of the purpose of the student's life and why he is there, and that it is essential to correct discipline. It brings out the idea that was mentioned of a student having a purpose in coming to college, and that very purpose sobering him and bringing him to decent living.

Another thing is the question of citizenship. There is no transformation that comes over a young man simply because he becomes a college student or any requirement that he should act differently from anybody else on the trains or elsewhere, and I think by presenting that point and keeping it constantly before the student, but in a common-sense way, the student will lose sight of the old stories that used to be told of how their fathers and grandfathers and uncles went off to college when few men went to college, and how they used to paint the town red and do a thousand different things. That is all being eliminated from college life, because students are becoming so common that they can afford to act like other people. We emphasize the point that the college is not only a preparation for life, but that the college is life; that every principle of life, every principle of decent living and decent citizenship that is in life is in that college. The man who is decent there is going to be decent outside, and the man who is not decent in college is not going to be decent outside.

The colleges of the country are concerned in having a high-toned moral sentiment in the student body, and that can be done only by making it understood that no young man can live in the college or can stay in the college unless headed in the right direction. I am trying to hold in mind, as president of our institution, the tendency of every boy, as to whether he is going in the right direction or the wrong direction. I classify every student that comes under my direction. As I step on the platform at chapel exercises, I can tell you whether a student is going in the right or wrong direction.

We do not have student control and we do not have faculty control when it comes to discipline. I do not believe in letting a question come to an issue. If you see a boy going wrong and you can not get him right, make him leave college. We cut off and trim down, so that it is hardly ever necessary that a case should be dealt with in a formal way, and in this manner we try to build up the correct public sentiment in the college. That is the main thing after all. It is the correct public sentiment in the college that dominates the college. I would not give a copper cent to keep any boy from doing this and that and the other simply by authority. But you want to get into him those fundamental principles and those high ideals of citizenship that will dominate the school, and the school just governs itself, because there are certain ideals you have got into the student body that the boy will not dare to offend against. When you get the student body to that point, then any correct discipline will carry with it the indorsement of the student body.

I think the next thing essential to discipline is sympathy and openness on the part of the college. The student body must always realize that those in authority are not seeking to find this and that and the other, but that the president of the college, if he is clothed with authority to administer discipline, is in sympathy with the student body, in sympathy with the very purpose and life of the student, and they must feel it at all times; and in order to do that the president must deal with them only. Speaking from personal experience, I never write home to a parent criticising or finding fault with a student, but have asked the student to come into the office and write home to his family. The boy must know that you are giving him a chance; and when you do that and use common sense, I think there will be no trouble in working out harmonious common sense in the way of discipline.

E. B. ANDREWS, of Nebraska. There are two or three specific problems that have not been touched upon by either of my predecessors in the discussion, and I will say a few words.

There is first the very specific problem of the college row. In the university where I am they are rare, but they bother me, and I am frank to state that they bother me more than almost anything else. I think they are a great pity, but I do not as yet see just how to right them. Of course if a student were hurt, I should urge him to prosecute, if I could get him to do so, the man who hurt him. Sometimes a student refuses to do this. I should also use the authority of the institution to find out who the guilty party was and discipline him still further. But the knowledge that that can be done does not always help to get proper relations or prevent improper relations for a short time between different grades and different gangs of men. In the institution where I am now the temper is better than any place in which I ever served where I could not have an audience room in which I could get my students together. The largest place of importance that we have would not house more than one-half of the students of the university. This makes exhortation of any kind exceedingly difficult and brings about an inability to impress noble principles upon the student body, and in the meantime our discipline troubles me at just that point. The best men in the university sometimes forget themselves and engage in class scraps. I do not believe the difficulties of one institution ought to be passed over to another, or to be blamed onto another, but every time these difficulties arise with us a few students recite the fact that other institutions are looking with tolerance upon the cane rushes and similar things. If that is so, I must express the opinion that I have expressed in these meetings many times, that I think it is a great misfortune. I do not see how you can help a regrettable occurrence of this sort if you do not frown on any sort of occurrence that is out of order. I lay down the proposition exactly along the line of what has been said before me this afternoon, that a thing that would be looked upon as disreputable and regrettable in the average town or city is to be looked upon as regrettable or contemptible in the great body of students, and if you do that on things intended to be innocent—like a cane rush, for instance—if your approval can be gained in such matters as that, I think you will be obliged to take up more serious ones. We have found that the little thing grows into the big and more regrettable thing, into matters of bloodshed and very serious personal injury, which, of course, after they have occurred, all persons speak of as regrettable occurrences. And yet we have never, where I have been, forbidden out and out that such a thing as a cane rush should be held. We have never passed a rule to the effect that any man who is engaged in any such thing should be expelled or should be dealt with, and this seems to be an advisable course. It works fairly well. Many a thing can be dealt with better by teaching against it, laughing it down, and calling it foolish, which it is, than it can be dealt with in any other way.

Another thing is the proper supervision of students in their own residences. We have no dormitories, and in the State universities and schools generally we do not have such. If we do have them, we have them in such numbers or with such capacity as to make it no longer necessary that students shall find their residences here and there. And I believe it was understood the other day when this matter was up in another meeting that there is a growth of the fraternity house. That is certainly so with us. How shall we deal with students in fraternal and sorority houses? They generally behave. I think in few fraternity houses there is drinking, which is to be deplored. I think all drinking is to be deplored, but what I mean is that sometimes there is a drinking bout. We try to get the resident members of the fraternities to intercede and bring influence in order to stop the practice, and sometimes they succeed and sometimes they do not. In all the places where I have ever had to do with the management of students I have often gotten the resident members of the fraternity or graduate members, even if I have to call them in from a residence elsewhere, to deal with their members and conferees in their fraternities who were undergraduates. Even this with us has not in all cases made it exactly right. In some of these houses some people do not study as they ought to, and take up more time in other things than they should. These things are not serious inconveniences, but they are troubles, after all, of a certain kind. But the worst problem, and I wish I could believe it was local purely, but I am afraid it is not, the worst problem is the disposition of a few students to crib, as we call it, in examinations. Perhaps that is the worst fault of American colleges to-day. It is with us a considerable evil. I do not think from what I have heard that it is worse with us than at other institutions of learning, but this trouble exists with us, and I do not for my part see just how to reach it. I can not think that in any considerable number of the institutions of this country it would be wise to leave the supervision of examinations to the students. I do not know whether it impressed other gentlemen as it did me when Dean Thornton of the University of Virginia was speaking the other day in one of the other meetings about the procedures that occurred in that eminent institution in the case of students cheating. The whole examination is practically, so I understood him to say, given over to the students. They are supposed to be on the watch, or at any rate no other watch is set than that which is spontaneously set by the students. And I think he said explicitly that unless a student who is charged with cribbing could make his fellow-students believe he was innocent he left the institution and never came back, and not only so, but the ill repute of this followed him through life, and that it was equivalent practically—though it was not his illustration, but my own thought—to being drummed out of the army, out of his regiment, or out of his corps, for desertion or cowardice on the field of battle. I do not know whether other people were affected the same way I was. I said that it was a hardship; that it is absolute injustice. If I lived in Virginia and had a son that was sent away in that manner and crucified for life and no trial was given him except that which would be instituted by his fellow-students I would do something. I would seek redress for my offspring if I could. If the laws of the State enabled me to get it, I certainly would get it. I can not think of anything more unjust. It may work very felicitously. It may save responsibility and trouble for the administration. But I am one of those who believe that the administration of the university ought to deal with all of those things, and that there ought to be strength enough and method enough in the administration of any university to oversee the examinations that are officially set, and that every resource of the university ought to be brought to bear to see that the examination is fair, and that it is actually taken. The marks that are gained on a large part of the examinations are of monetary value when a man graduates, and how terrible a thing it is that a man shall get by cheating a chance to earn a salary which but for his cheating a fellow-graduate might have been able to earn in his place, and he earns the money without deserving to earn it. Such cases as that are rather rare, but such cases might arise if we do not properly supervise our examinations. We have made some effort in the University of Nebraska to check this evil, and with considerable success. A number of students since I went there have been sent away for participation in this great crime. I always try to explain that it involves the crime of lying. If it is the usual written examination, he has to write only that which he has found out by his books in a proper manner and not take from anybody else there and write down matter which he has gathered out of a book and made notes of on his cuff and that does not properly represent his own mind. And, further, he is obtaining a credit to which he has no strict moral right. There is, therefore, all of the moral turpitude of lying and bad faith.

All of our men who graduate in technical departments can have occupation the very next day after they get their diploma if they are willing to take it. Civil engineers have that chance, mechanical engineers have that chance, electrical engineers have that chance, and graduates in agriculture have that chance, and I for my part feel that no man ought to steal his way to that degree, but that if he gets a certain salary he ought to earn it. Of course it is easy to say that probably even if a man does crib now and then he earns his degree. I think he ought to earn it entirely. I should feel wicked if I had any part in letting a man secure a degree in any institution of learning where I was placed unless I felt that he earned every particle of the credit brought by that degree.

These are the three specific problems, Mr. Chairman, that have come to me as I have listened to these interesting and valuable remarks, based upon such experience as I have had.

W. O. Thompson. I should like to say a word or two in view of my paper and the subsequent remarks, and I desire to address myself specifically to two or three things which Chancellor Andrews has brought out. For instance, the class contests. I do not want any inference that we do not have such things in Ohio. We have them every year. I think it can be said honestly that we had the best class rush in America this year. We open our schools for registration of the students on Tuesday. We have the machinery so we can register 1,500 students, who are installed regularly. On Wednesday we deal with the irregulars. Then comes the day with a clean card, and the Y. M. C. A. always give a reception on Friday night. On Friday at 4.30 the rush is on. I can not go into all the details, but I have put the proposition to the student body in this way: That a contest between classes is just as fair as a contest between football elevens, provided it is a fair, square, and manly contest, and under no other terms would I be satisfied. Now, I do not want any college rushes, but if we are going to have this sort of thing we will do it just as reputably as a football team in its contest with another team. They have agreed to that. Now they come in to me the very first day and say, "Mr. President, the distance is measured off and everything gotten ready," and I go out in the field at the appointed time and take charge of it, and when the whistle blows the rush stops. The truth is I have taken seventeen-twentieths of the glory out of it, and nobody goes into it unless he wants to do so, and the result is that they can not get anything like 6 per cent of the students to engage in it. I can not go into the details of that now, but it is recognized that "Prexy" has the situation in his hands. For instance, they have got a cane and they have got a certain distance, and I go out in the middle of the field. They are already in their place. When I give the signal, they start. We had over 5,000 people come up to see the rush last fall, and they came in automobiles and carriages and everything else.

Now, the truth is that these fellows respect me in that situation. I have the assignment of rooms. Whenever an executive order goes out it has got to be obeyed, and if a fellow does not obey he will go from the college quickly. One rule is that no meeting can be held in any university room without the consent of the president. So if I assign the sophomores a room they can have it, and anybody disturbing that meeting will have to get out of the university. If any university organization wants a room, I will say to them, "I will be glad to accommodate you provided somebody has not been here before and got the same accommodation, but you must never interfere with anybody else." The result is that we do not have any kidnapping business. I have never had any disorder with that sort of thing. Now, I use that simply to illustrate that I believe in the administrative principle. They would not think of having anybody else as referee and would not think of doing anything until they got Prexy's consent. So much for that.

I will give you an illustration of another matter. I have never revised a decision since I have been a college president, and what is more, I never will. I am very slow to make them, but when they are made they are made. A few years ago our glee club went to Marysville; a reception was given them, and about 1 o'clock in the morning they got home drunk. That was about five years ago, or six. I had happened to come to Washington at the time. As soon as I returned to Columbus I went up to Marysville and saw the register of the names of the students that had stopped there. I sent for these young men to come in and see me. I told them that I had not read a paper. I said: "I want you to tell me of your own free will just what happened as far as you are willing, but I do not want you to incriminate yourselves." Everyone admitted the truth. I sent a second notice, saying: "Now, I want you to come in a second time, to show why you should not be suspended from this university." Every man came in. They went over the thing, and every last one of those fellows went out of college. They went out until the next June. Several of those boys came back and graduated, and are the warmest personal friends I have in the State of Ohio to-day. I never have suspended a student from the university who did not first say that he ought to be suspended. I stand toward a student disorder just exactly as I would stand toward a disorder if I was President of the United States. I say: "The law has got to be maintained, and you get right out of here. If you want to have a class rush, you can not have one if it is disorderly, and whenever you are disorderly and that fact comes to my knowledge you will get out of this institution right there and then." And I issue the order. I believe in the supremacy of the law there. The State universities and agricultural colleges stand under the law of the United States as democratic institutions in which the supremacy of the law is to be regarded. I have never suspended a student when I was angry in my life. I have never disciplined a student until he was brought face to face with me and stood in the presence of his fellows, and the result of that is that they know if anything goes wrong with a student I wish to see justice done. I would miss any important engagement in this country if the question of a student's welfare were at stake. I want the students to feel that if they get up to the president they will have a square deal. After all, we have got to administer these great trusts as men, and I would not, if my honor, my integrity, my truthfulness, were impugned, in an institution, be president twenty-four hours. I believe this whole question of college administration and discipline is solved when you lead a fellow to come right to you and do the right thing, although you have to suspend him from college.

The other day a man called me up about the employment of a certain young man. I informed him that he was all right; that I had suspended him from the college, but that I would guarantee him now. He said: "That is a curious remark, but I will take him." The boy knows that I stand by him. I tell you there is a mighty saving power in the spirit of justice, dealing fairly and squarely in these propositions. What I despise of all the things in some of these places is the disposition to cover things up and get away from them

In that matter of examinations I have suspended a number of men from the university, and I have never failed to suspend a man for the remainder of the year. I face him with it and ask him to present the situation, and if he is guilty of that sort of thing out of college he goes. There is no other penalty. He understands that when the time has expired he has served his penalty and that he is free again to come back just as he came in originally, and without any discrimination whatever.

E. B. ANDREWS. May I say just one word as to the official rush? I wish I could see some merit in it. On the other hand, I can not see it at all. Such a thing with the students I have to deal with I know would work evil. I can not see how it can fail to work evil at the Ohio University or any other place. And I have never in all my life heard, outside of college communities—and we are talking of the civic administration of college people—I have never heard of anything of that sort taking place, at least not as a regular thing. It is always a spontaneous outburst; it is unpremeditated, and so is not the thing President Thompson is talking about. I think in all the companies of students that I have been associated with the official rush would lead right straight back to barbarism.

K. C. BABCOCK, of Arizona. I have had experience with two institutions, and at one it terminated in a row. The other was at the University of California, where they had a barbarous night rush. They had an official rush one year. After that the faculty smashed the whole business.

The CHAIRMAN. President Thompson, how do you take care of things when you are not there? Do you have a faculty system or a system of proctors?

W. O. THOMPSON. As far as taking care of things is concerned, I think I am always there. At least my inspirational presence. I am rarely absent. This is the longest absence this entire year for me at any one time. I stick pretty close to the machine. But in temporary absence I appoint the dean, who will have charge, and whatever he says will go. All of the other details are in the hands of the executive clerk.

Thereupon the section adjourned for the day.

AFTERNOON SESSION, THURSDAY, NOVEMBER 16, 1905.

K. C. Babcock, of Arizona, presented the following paper:

THE LAND-GRANT COLLEGES AND NORMAL SCHOOLS.

For the purposes of this discussion, normal schools must be differentiated into two classes—the city normal school, preparing teachers for urban conditions, and those normal schools, by far the greater number, which prepare the teachers for the schools of the small town, village, and rural community. The land-grant colleges can not, in the nature of the case, expect to influence very powerfully, on the agricultural side, such normal schools as those in New York City, Cook County, Ill., or San Francisco, Cal. But in the case of schools like Cortland and Oneonta, N. Y.; Platteville, Wis.; St. Cloud, Minn.; Greeley, Colo., and Chico and San Jose, Cal., very much that will be vitally and permanently profitable can and must be done. Just what should be undertaken, and just how to proceed in this period of transition to a deeper and more scientific interest in country industrial life, are questions which must be settled slowly by a combination of common sense, a little pedagogy—not too much—and a great deal of thoughtful, painstaking, patient experimentation. Some suggestions are certainly opportune at this time.

Under pressure of circumstances, under stress of scant means, under the incubus of cocksureness on the part of those method-ists who have solved all the educational problems of life, death, resurrection, and the world to come, the children of the rural school, of the suburban residential community, and of the crowded sections of great industrial cities, are all treated to substantially the same medicine. All ignorance and all lack of interest look pretty much alike to the teacher narrowly trained in the still pervasive pedagogic notions as to right methods and times in arithmetic, reading, geography, and history. A certain New England preacher of a by-gone day was asked how he had managed to bring up a family of ten children on the unprincely salary of $400. His reply was that he found out the food the children did not like, and gave them lots of it. In the rural schools this principle has been applied all too consistently, and the chief marvel is that more men and women have not been spoiled in the making. Thirty years ago, and perhaps last year, graduates of the best normal schools of New York taught in the small villages of that State, with a serene and blessed indifference to nearly everything which distinguished country life from city life. Of course the principles of mathematics and of good English are the same everywhere, and there is no short toll road to the knowledge of them. But no one familiar with the conditions of country schools and of grade schools in the cities for that matter will attempt seriously to controvert the statement that there is lamentable waste of time and energy in all the primary and intermediate work. Great accumulations of material are unutilized for educational purposes in the country schools.

It is clear that there is a strong tendency in recent years to raise higher and ever higher the standards of requirements for teachers' certificates. The high schools want teachers who are college graduates. Grade school officers, backed in some States by statutes, require graduation from a college or normal school as an element in the qualifications of their teachers. All this is good and praiseworthy, but it does not seem likely to remedy all the ills which might be ranked as major. Those who are interested in raising the standards of living in the country, who want to increase the prosperity, deepen the contentment, and cement the attachment of country boys and girls to the life of the farm may well consider the normal schools as an open door into which they may enter with missionary zeal to preach to, convert, and inspire those who sit in darkness. If the children of this generation are to be kindled into real enthusiasm for the wonders and possibilities of their surroundings, if the drudgery of their daily routine is to be enlivened by a vision of the past and present processes of nature, it must be done by better teaching in the lower schools, by teachers who have knowledge and fire to be passed on to their pupils. To this end the land-grant colleges and the State universities must cooperate with the normal schools—compel some of them if need be—to prepare teachers far more effectively for instruction in the rural and village schools. Some of the normal schools have already gone far to meet the legitimate demands for teachers prepared for the organization of courses in manual training—for example, the Cook County Normal School. Here and there a strong school like the San Jose Normal School in California offers a course in elementary agriculture, but even this is not required of any particular class. However, with all these gains, scarcely more than a beginning has been made.

Mere knowledge of facts and methods will not suffice, since the aim of the reforms or changes under discussion is not so much addition to the already crowded curriculum of the public school, as it is an attitude of mind which will enable the teacher and pupils alike to understand and sympathize with the conditions under which such a vast number must live and move and have their being. Since the object is the interpretation of known facts, the infusion of interest into what has been but half known and wholly unappreciated, knowledge of how to manipulate the material at hand, how to correlate its sections, how to vivify it, becomes of cardinal importance, and right here the function of the normal school gains new significance. The normal schools must serve as educational transformers. The colleges and universities at this stage of the game are like great dynamos, furnishing scientific information and training and generating interest in the subjects to be taught. The normal schools must take this powerful, high-tension current and reduce it to such form that it may be safely and continually used by the millions with profit and cumulative satisfaction. The land-grant colleges may apply their knowledge directly, as at Cornell University and Iowa State College, through farmers' institutes, publications, and correspondence, and short sessions on an untechnical basis. In this way many adults of the present day may be reached, but the process viewed as a reformative measure is unsatisfactory—a palliative rather than a cure. To change the figure, it is but setting a few grafts well out on the limbs of a mature tree from which will come some improved fruit; while what is really needed is an early graft of the sapling, so that all its fruit shall be good, so that all the sap from the common earth and all the forces from the common air shall go to make fair and luscious fruit, not small, sour, scrubby, useless apples or grapes.

Cooperation of the land-grant colleges and the normal schools in this high endeavor has hardly begun. The initiative must certainly come from the college side, where the need is most appreciated and where the knowledge is ready for transformation and transmission. Assuming that these colleges are prepared, by their courses in the sciences and arts most applicable to country life, by their lectures within their own walls or in extension lectures, and through the workers in connection with the experiment stations, to furnish the teachers of teachers with equipment for their work, what may be asked of the normal schools? First, and most fundamentally, that they impress upon those whom they graduate the necessity of adapting the work in English, especially in composition, all through the grades, to the facts, experiences, and ideals of the real and enlarging life of the child in the community—less imitation of the stilted language of the readers and the literature prescribed and more of the natural expression of the thoughts that properly fill a boy's mind; less of "Snowbound" and "Planting the Apple Tree" for pupils in southern California, and more of the planting and care of an orange orchard, or the ways of getting and using water for irrigation. Second, that the work in nature study be enlarged and steadied, relieved of the air of sentiment which too often envelops it, and turned specifically in the direction of agriculture in those schools which train largely for nonurban schools—the ways of brooks, the sorting and germination of seed, the ways of animals, the meaning of temperatures. The normal schools may reasonably claim the active cooperation and assistance of the land-grant colleges in this training of teachers. Courses of lectures could easily be arranged in subjects related to the topics just mentioned in such normal schools as Oshkosh, Wis.; Winona, Minn., and Charleston, Ill., by the staff of the land-grant colleges of those States; nor ought the men selected to give such extramural courses to be required to give them in addition to full regular work in their home institutions. Such courses should be counted as part of the regular duties of certain professorships. Short courses and summer courses may be made to serve the same purpose, though in such cases the prospective teacher may be required to go to the lecturer in place of the lecturer going to him.

In view of the new and hopeful demand for betterment of conditions of life in the country, it does not seem unreasonable to expect that the day is not distant when teachers applying for positions in the villages and in the country will be required to present evidence that they have taken courses along the lines suggested in this paper, by which they will be prepared for intelligent stimulation of enthusiasm for the wholesome life of the country in the minds of those who shall soon shape the course and sentiment of the vast agricultural population.

W. J. Kerr, of Utah, presented the following paper:

THE RELATIONS OF THE LAND-GRANT COLLEGES TO THE STATE UNIVERSITIES.

From the time of the establishment of the land-grant colleges, the question has been agitated, in one form or another, as to the extent and character of the field these institutions should occupy; the relations that should exist between them and other colleges and universities. During recent years the people have become better acquainted with the work the agricultural and mechanical colleges are accomplishing in promoting industrial education and the development of the industries and resources of the country; and, consequently, there is a better understanding regarding the functions and scope of these institutions.

Even yet, however, there is a divergency of opinion on these questions. In some of the States there is still an agitation of the question as to whether the land-grant colleges should be primarily or exclusively trade schools, their object being to train farmers' sons for the practical work on the farm, and tradesmen in blacksmithing, carpentering, and other handicrafts; or whether they should be strictly educational institutions of college grade. If the latter, should they be schools of agriculture only, or should their scope be broadened to include other courses? What place should these institutions occupy in the public school system of the country? What relationship should they bear to the State universities?

That these important questions are not yet definitely settled, and that there is no general agreement upon them, even among educators, are conclusions justified by the recent controversies in a large number of States about the distinctive spheres of the universities and land-grant colleges, and the widespread agitation, throughout the Middle and Western States at least, of the question as to the policy that should be pursued in the development of the State institutions of higher education. For example:

In South Dakota, last year, the governor, in his message to the State legislature, reprimanded the State university for unduly emphasizing, as he thought, the work in engineering; and censured the agricultural college for offering courses in Latin.

In North Dakota, two years ago, the governor recommended to the legislature that unnecessary duplication of courses in the State university and the agricultural college be avoided, and that "each institution should be kept within its special sphere."

In Iowa, the legislature appointed committees to visit the different State institutions for the purpose of investigating their needs and reporting on the appropriations required. The committee appointed to visit the university recommended in its report that the engineering courses offered in that institution be discontinued, and that all engineering work be concentrated in the College of Agriculture and Mechanic Arts. However, the legislature made the usual appropriation to the university for the maintenance of the engineering courses, and a special appropriation for an engineering building; but appointed a commission to consider the advisability of putting all State educational institutions under a general board of control.

In Colorado a bill was introduced in the legislature providing for the appointment of a commission to adjust the work of the State University, the Agricultural College, the State School of Mines, and the State Normal School. The introduction of this bill was the result of the agitation that had continued for a number of years regarding the respective fields that these institutions should occupy in the higher educational work of that State.

In Utah, after a protracted struggle between the university and the agricultural college, extending throughout the entire session of he last legislature, over the question of uniting these institutions or of transferring all engineering courses from the college to the university, a bill was finally passed providing for the appointment of a commission to investigate the question of college and university work, and to report, with recommendations, to the next legislature.

For a number of years the people of Montana were agitating the question of the advisability of consolidating the university, the mining school, and the agricultural college. In 1902, under the authority of the legislative assembly, the State board of education carefully investigated the work of these institutions and the conditions relating thereto, and by unanimous vote "declared that it was not feasible to attempt consolidation." The governor in his message to the legislature in 1903 expressed the belief that a further agitation of the question would accomplish no good and would "be altogether harmful to the State and detrimental to the cause of higher education."

On the other hand, in Idaho, where the land-grant college and the State university are united, a strong effort was made to secure the passage of a bill separating these institutions. While no definite action was taken at the last session of the legislature, there is still a strong feeling among a large number of the people of Idaho in favor of separation.

In Wyoming, also, there is talk of dividing the State university, and maintaining the land-grant college as a separate institution.

In California $150,000 was appropriated by the last legislature for the purchase of a farm to be used in connection with the work of the agricultural college. Suitable land, it is said, can not be secured in sufficiently large quantities in the immediate vicinity of the university, and advantage is taken of this to agitate the question as to whether the land-grant college should not be separated from the university.

In some States, where the land-grant colleges are associated with the State universities, difficulties have arisen over questions relating to the rank of the colleges or departments of agriculture and mechanic arts with the other colleges or departments of the university. This was particularly true during the earlier history of these institutions.

The conditions affecting the work of the State universities and the land-grant colleges are so diverse and depend so largely upon local environment that it seems impossible to work out a general plan that shall be applicable throughout the country. But it should not be impracticable to reach an agreement upon a number of the most important matters bearing upon this question. In order to determine the relations that should exist between these institutions it is necessary to consider, first, the origin of State universities and the objects in view in their establishment; second, the function and scope of State universities prior to 1862; third, the origin of land-grant colleges and the purposes of their establishment; fourth, the concurrent development of State universities and land-grant colleges since 1862; and, fifth, the present scope and character of these institutions.

The limits of this paper preclude anything like a complete discussion of these questions. As a basis for the conclusions which are to follow, however, it is important that brief reference be made to at least a few of the leading features.

The origin of the State university dates back to the famous ordinance of 1787 for the government of the Northwest Territory. This ordinance declared it to be the duty of the nation to support education, and reserved two townships of public lands in each State for the maintenance of seminaries of learning. The States which were subsequently organized out of the Northwest Territory carried out the educational provision of this ordinance, and through thirty-two separate acts of Congress, passed largely during the first half of the last century, all of the States west of the Mississippi received similar land grants for the endowment of universities. Under these acts approximately 1,500,000 acres of land were granted for the endowment of institutions of higher education in twenty-two different States and Territories. The purpose in view was the establishment of a university in each State, under the control of the Commonwealth, to promote, in the language of the ordinance "good government and the happiness of mankind." The character of the work contemplated for these institutions is indicated in the provision of the ordinance which declares that the land granted should be used for the support of a "*literary institution*, to be applied to the intended object by the legislature of the State."

The oldest of these State universities established under the ordinance is the University of Michigan, founded in 1837. The University of Missouri was established in 1840, and the University of Wisconsin in 1848. Most of the other State universities have been established since 1868.

At the time of the passage of the Morrill land-grant act in 1862 the accepted type of higher education was the four years' course of the old classical college. The conventional courses in classics, literature, and philosophy were the leading features of college work. The State universities were expected to be, as it was declared in the organic act that they should be, *literary institutions*. They were confined for the most part to the traditional courses of the time, and differed little, if at all, from the old classical institutions.

During the years immediately preceding the passage of this act, extending over a period of about two decades, great progress was made in the development of the country, and there was an increasing consequent demand for trained men for responsible positions in the different industries. As stated by President Dabney, "great railroads were to be built, but with the exception of the Military Academy at West Point, there was no school to train the engineers to survey them. Mines of coal and iron were to be opened, but miners had to be imported to open them. Factories needed to be built, but engineers had to be brought over from England or Holland to build them. Ironworks and many other important industries were calling loudly for chemists, who had to be obtained from Germany or France." Moreover, the impairment of the natural productiveness of the soil, the depreciation of farm crops, and the resultant general deterioration of farm properties were earnestly calling for the remedial applications of scientific methods in agriculture. It became evident, therefore, that the old college was not meeting the new demands. A new type of education was required, an education bearing more directly upon the arts of life.

It was to meet these particular needs of the people in the development of a new and rapidly growing country that the Morrill Act of 1862 was passed. Under this act nearly 11,000,000 acres of lands were granted to the different States for the endowment of colleges, the leading objects of which should be "to promote the *liberal* and *practical* education of the industrial classes in the several pursuits and professions of life." As explained by Senator Morrill, "the fundamental idea was to offer an opportunity in every State for a liberal and larger education to larger numbers, not merely to those destined to sedentary professions, but to those much needing higher instruction for the world's business, for the industrial pursuits and professions of life." It is clearly evident from the provisions of the Morrill Act, and from all the speeches delivered in Congress relating thereto, that the object was to provide for a new type of institutions, occupying a distinctive field as scientific, technical colleges, adapted to the needs of the great laboring classes in the development of the industries and resources of the country. But it is also to be observed that a *liberal* as well as a *technical* education was contemplated—an education for skill and efficiency, but for culture as well. The purpose, therefore, in the establishment of the land-grant colleges was to provide an education, to quote again from Senator Morrill, which "should prove useful in building up a great nation—great in its resources of wealth and power, but greatest of all in the aggregate of its intelligence and virtue."

The development of State universities and agricultural and mechanical colleges since 1862 involves largely the history of the growth of higher education in the United States under Federal and State control. While great interest had previously been taken in higher education, there was special emphasis at this time upon the necessity of the colleges and universities affording opportunities for the special training required in the development of the civic institutions, and particularly of the economic interests, of the country. The passage of the Morrill Act gave new impetus to educational endeavor and resulted in a general effort to secure the establishment of a college or university under the direct control of the Commonwealth in each State and Territory. During the first decade no fewer than twenty-four State institutions of higher education were established. As the country developed and new States and Territories were organized colleges and universities were founded, until at present every State and Territory except Alaska maintains at least one such institution. Some of the States combined the land grants of the Morrill Act with those of the ordinance of 1787 and the supplementary acts of Congress for the establishment of State universities, but most of the States kept the Morrill grants separate and established special colleges of agriculture and mechanic arts.

Thirty-eight State universities are now maintained in as many different States and Territories. Of these 20 are land-grant institutions, of which 16 were established after 1862 and owe their foundation to the Morrill Act, while in four of the States the land grant went to existing institutions.

There are 65 land-grant colleges and universities established in all the States and Territories except Alaska. Of these, 20 are united with State universities, and 15, under the Morrill Act of 1890, are maintained in the Southern States for colored students.

In 1903 the aggregate income of the State universities was approximately $9,750,000, and the value of their equipment and permanent funds was nearly $55,000,000. More than 45,000 students were in attendance, and the number of persons in the faculties exceeded 3,600. In connection with the above it is interesting to note that the 18 universities which do not have the benefits of the acts of Congress of 1862 and 1890 had a total income of less than $3,000,000, with equipment and permanent funds estimated at less than $15,750,000; while the attendance was 16,400 and the number of instructors about 1,200.

The statistics of the land-grant institutions for the same year are as follows: Income, $10,700,000; value of equipment and permanent funds, $70,000,000; number of students, 52,500; number of instructors, 3,600. During the year 1904 there was an increase in the revenue of $2,300,000, in the value of property of more than $3,516,000, in the attendance of nearly 4,000, and in the number of instructors of more than 700.

As has been stated, the first universities which were established under the ordinance were much the same as the old colleges of the time and were confined mostly to the classics, literature, and philosophy. But the factors which combined in securing the passage of the Morrill Act of 1862 were also potent throughout the country in modifying public opinion on questions of educational policy, relating not only to the work of the proposed institutions of higher learning, but also to the directions in which the existing institutions should be developed. The people of Wisconsin, for example, in 1858 demanded that in the university of that State "a more distinct bias should be given to its instructions in the direction of the several arts and avocations as they exist among men." With the development of the State universities, therefore, there has been a general broadening of their sphere and a gradual introduction of professional and technical courses, until at present these institutions may be said practically to cover the entire field of higher education, the scope and character of the work offered being limited only by the extent of their income.

The function and scope of the land-grant colleges are clearly defined in the Federal law, which declares that "the leading object" of these institutions shall be, "without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts * * * in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." The supplementary act of Congress of 1890 further emphasizes the character of the work that shall be provided for in these institutions, wherein it specifies that the money appropriated shall "be applied only to instruction in agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural, and economic science, with special reference to their applications in the industries of life."

It will be observed that particular stress is placed upon the "leading object"—to apply science "in the industries of life;" to promote the education, "liberal and practical," primarily of the "industrial classes," not only in the "several pursuits," but in the "professions in life." There is special emphasis upon "agriculture and the mechanic arts," and also upon the "branches of learning" related thereto, "without excluding other scientific and classical studies." As interpreted by the Department of the Interior, and agreed generally by educational authorities, the "mechanic arts" of the Congressional acts are not confined to mere manual training in the handicrafts, but comprehended the most extended courses in engineering—civil, mechanical, electrical, irrigation, etc.

It is evident, therefore, that the work of the land-grant colleges should cover a broad field, including not only the technical courses required in the development of the varied industries and resources of the country, with thorough training in all of the fundamental cognate sciences; but also the general training in language, literature, history, and civics, which constitutes an essential part of a liberal education. While the distinctive features are made clear and emphasized, there is no inhibition as to the extent of the courses to be offered; and hence there are really no limitations to the scope of these institutions except those conditioned by environment and income.

What, then, should be the relations existing between the land-grant colleges and the State universities?

(1) In the States where these institutions are united the agricultural and mechanical departments or colleges should be coordinate with the classical, literary, and other departments or colleges of the university. Since the universities in these States are essentially land-grant institutions, receiving the benefits of the income derived from the funds of the land-grant act, and the appropriations of the acts of Congress supplementary thereto, it is consistent to assume that the distinctive features of the land-grant colleges should be emphasized and given at least equal recognition with the other courses.

(2) In the States where the agricultural and mechanical colleges and the State universities are maintained separately, particularly in the newer States with comparatively small population and limited revenues, it is important that

the respective functions of these institutions should be clearly defined in such way as to avoid, as far as practicable, the duplication of expensive courses, and to prevent either institution from encroaching unnecessarily upon the distinctive field of the other.

(a) In the land-grant colleges special emphasis should be placed upon the applications of science. Scientific investigations should be encouraged, but with the view of their practical value rather than for the purpose merely of extending the borders of knowledge. These colleges are primarily schools of technology, in which agriculture, the mechanic arts, domestic economy, and commerce may be regarded as distinctive features, the extent to which each institution should develop courses along these different lines varying with the conditions in the several States.

(b) The State universities in such States should give prominence to the work in literature, classics, philosophy, and such professions as law and medicine. It should be recognized that one of the chief functions of the university is to encourage literary and scientific investigations, to discover truth for its own sake, to increase knowledge independent of the question of its possible applications.

(c) The logical division of work between these institutions would be to have all of the technical courses in the college and the literary, classical, and professional work in the university. But this plan would not be feasible in all of the States. Local environment and policies previously established must largely govern in the final adjustment of this question. For instance, in some of the States certain engineering courses might be given more advantageously in the university; but in any case, in the States under discussion, the same expensive technical courses should not be given in both the college and the university.

(d) Whatever division may be made of the engineering courses, the work of the college should be that which relates most directly to the development of the resources and industries of each State, such, for example, as the irrigation enterprises so important in the reclamation of the arid and semiarid regions, or certain manufacturing interests in other sections of the country.

(3) In the older and more populous States, such as Michigan, Iowa, Indiana, and possibly Kansas, the work of the State university and the college of agriculture and mechanic arts might consistently cover a broader field, each institution offering certain courses given by the other, particularly in engineering. But even here a wide variation in the methods of development and in the extent and directions of application will no doubt be found in the same courses offered by these different institutions.

(4) In any event, however, whatever the final division of work between these two institutions, and to whatever extent certain courses might be paralleled, even in the wealthiest States, each institution should still occupy a distinctive field, to the extent at least (1) that the State university should not offer courses along any of the different lines of agriculture; and (2) that the agricultural and mechanical college should leave the field in the liberal arts and in the professions of law and medicine exclusively to the university.

(5) In the foregoing discussion the word "courses" is used to cover the requirements for a degree. However desirable, and to whatever extent it may be practicable, to avoid a duplication of courses in the land-grant colleges and the State universities, it is impossible that a large part of the general work of these institutions should not be the same. As already indicated, and as clearly shown in the previous papers read at this convention, the distinctive courses of the land-grant colleges rest fundamentally upon thorough and extended training in the mathematical, physical, and natural sciences. These sciences must also be taught in the State universities. Moreover, both institutions should afford the general training in language, literature, history, civics, etc., required in a liberal education. The modern demands in education forbid that any State institution of higher learning should be confined to a narrowly prescribed course of instruction. Along with the distinctive work in any of the technical courses the demand for a liberal training is imperative and can not be ignored. In the language of Doctor Jordan, "education in literature, philosophy, and the sciences is now more than a luxury, more than the possession of the recluse, more than the necessary equipment of the old-time professions; it has become essential to modern industrial life and a potent factor in industrial progress."

(6) After all, the question which is being agitated in different States regarding the relations which should exist between the land-grant colleges and the State universities is largely a question of income, and can not be settled merely

by prescribing the work, by legislative enactment, or otherwise, which each institution should offer. So long as these colleges and universities are dependent for support upon periodical appropriations from the legislature there will always be controversies sure to arise regarding the amounts each institution is entitled to receive from the State. These widespread agitations are not only expensive, but prejudicial to the interests of higher education. It is important, therefore, that some means be devised by which permanently to adjust the difficulties and establish more harmonious relations between these institutions. In connection with the foregoing the following plan is suggested:

(a) That a thorough investigation be made under legislative authority to determine the proportion or amount of the annual State revenue that can be devoted to higher education.

(b) That a similar investigation be made of the work and requirements of the institutions of higher learning to determine the proportion of the amount provided by the State for higher education that should be given to each institution.

(c) That a statutory levy be made on all the assessed valuation of State property sufficient to provide each institution with the required annual income.

If this plan were adopted as a permanent policy (1) it would provide a regular fund, which would increase with the growth of the State; (2) it would insure a more stable higher educational policy; (3) it would enable the boards of control to know approximately what their income would be for years in advance, and thereby to plan their expenditures more wisely and more systematically; and finally, (4) it would relieve the State of the embarrassing and expensive contentions, at each recurring session of the legislature, over the question of appropriations for the land-grant college and the State university, and the attendant controversies regarding the respective functions and the comparative value of these institutions.

A. C. True, of the Office of Experiment Stations, presented the following paper:

The Land-Grant Colleges and the Public Schools.

The door of opportunity for the land-grant colleges in their relations to the public schools swings both ways. The colleges need to aid in strengthening and improving the schools, because from them must come the great majority of the college students, and it is therefore highly important that the public schools shall give the right kind of preparation for the courses offered in the land-grant colleges. The door between the colleges and schools must have the right inward swing. But the colleges should also ally themselves closely to the public schools in order that the schools maintained by the people may feel the inspiration of the great educational motives on which the system of land-grant colleges is based. And therefore the door between the colleges and the schools should swing easily outward and the college men and school men should frequently pass to and fro through it.

The fundamental thing is that the public school system should be efficiently organized to meet the educational needs of the masses of American youth, and therefore, like the land-grant colleges, it should provide an education which, whatever else it does, should directly aid the "industrial classes," constituting the vast majority of our population, to succeed in the several pursuits and professions of life. Ninety-four per cent of American children do not get beyond the common school; 4 per cent attend the high schools, and less than 2 per cent receive any instruction in colleges of any kind. It is obvious that the main purpose of the public schools should be to prepare for life, rather than for college.

Our school system has been the outgrowth of a plan of education framed to meet the requirements of the favored few who, under an aristocratic social scheme, were destined for leadership in letters, statesmanship, medicine, law, and theology. Such modifications as it has thus far received as the masses have come into the public schools have mainly tended to direct the youth to those pursuits in which manual work is reduced to a minimum. The great industries of agriculture and mechanic arts in which most of our people are engaged have thus been discriminated against in our system of public education, and the minds of our people have been prejudiced against them in the schools maintained at public expense.

Obviously this is wrong, but grave as this offense is it is not the only injury wrought by such a school system. For of late the wisest educators have come to see that the training of the hand and of the practical sense which may be given through instruction directly related to industries is an essential and valuable feature of a complete education and should be given to all children, whether they are destined to make manual arts their life work or not. In other words, the ideals of education should be changed so as to take in man and his environment as a whole, rather than part of man and part of his environment.

Since it is for this broader view of education that the land-grant colleges especially stand, they should actively exert themselves to extend the range of this new ideal of education until it permeates our entire educational system. In doing this they should not permit the adherents of the old educational ideals to claim that the land-grant colleges favor an industrial as distinguished from a cultural education. To set these two ideas over against each other is most unfortunate. It is an education truly and completely cultural that we should demand, and our insistence should be that no education can be completely cultural which does not contain the manual or industrial element.

Under the terms agriculture and mechanic arts in their broadest application may fairly be included all the dealings of man with the natural world (i. e., with the mineral kingdom and with plants and animals) for his own advantage, and in a true sense agriculture and mechanic arts are just as much a part of the common life of mankind as music, language, or mathematics. For this reason studies in agriculture and mechanic arts should be a constant element of the entire educational system. In the lower schools we should not seek to introduce teaching of particular industries and trades in agriculture and mechanic arts, but rather instruction in those facts and principles which lie at the basis of all agriculture or mechanic arts and those operations which form a natural introduction to all agricultural industries and mechanical pursuits.

There is, I judge, no necessity in this association to argue in favor of such an ideal of education, for we are already committed to it. The question we need to discuss is how can we best exert our influence to secure the practical application of this ideal in our public schools.

To make their activity for the promotion of newer ideals of education effective in connection with the remodeling of our public school system the land-grant colleges should do specifically the following things:

(1) They should study the programmes, text-books, and equipment of the public schools and formulate desirable changes in them.

(2) They should in various ways come into close touch with the school officers and teachers and by precept and example strive to show them a better way of educating the masses.

(3) They should provide at the colleges courses of study which will be attractive to school officers and teachers, and by summer schools or otherwise seek to bring such persons into direct contact with the system of education represented in these colleges.

(4) They should turn the attention of their students to the importance of the work of teaching and guide a considerable number of them into positions as school officers and teachers. This is very important. Hitherto the principals and teachers in our public schools who have received collegiate training have for the most part come from those colleges which represent the old type of education, and their influence has been predominant in our educational affairs.

(5) They should instruct the community through such agencies as the public press, the farmers' institutes, and other organizations with which the college is accustomed to work, regarding the changes required to improve and perfect our system of public education.

The movement for the introduction of the industrial element into our public schools generally is already well under way. The elements of mechanic arts (including domestic arts) and the elements of agriculture (including what is commonly called nature study) are now taught in hundreds of public schools in different parts of the United States. In more than 40 States the teaching of mechanic arts (under the name of manual training or domestic science) in public schools is authorized by law, and the same is true of agriculture in some 30 States.

This industrial instruction has thus far been largely confined to the city schools, but is now spreading to the villages and even to the country districts. To secure a much wider recognition of the industrial element in public education, an active propaganda by its advocates will bring large results within the next few years. In this work the land-grant colleges and the organizations intimately connected with them might well take a leading part.

Turning now to the other side of this question, the land-grant colleges need to take an active part in the establishment of elementary and secondary courses in agriculture and mechanic arts in the public schools, because such courses are required to direct students to these colleges, and to prepare them to enter the college courses in these institutions. Many of the land-grant colleges are already embarrassed by the rapidly growing influx of students not well prepared to enter courses in agriculture and mechanic arts, if these courses are of a grade strictly equal to those offered in the sciences and humanities. Thus far the demand for industrial education in the land-grant colleges has been largely met by preparatory and special courses of low grade or by keeping the general requirements for admission down to a comparatively low level. This has led to many embarrassments as regards funds, equipment, teaching force, degrees, etc. Following the general course of development of American colleges and universities, the land-grant institutions are more and more endeavoring to raise their entrance requirements and make the requirements for degrees accord with the standards established by our oldest and best colleges. To do this successfully the land-grant colleges need to have many secondary public schools as feeders, and also to satisfy the rapidly growing demand for industrial education of lower than college grade, which is even now causing so much embarrassment to the colleges, and which in the near future they will not be able to meet at all.

In his recent inaugural address, President James, of the University of Illinois, called attention to this as related to the further progress of that university, and used the college of agriculture as a specific illustration of this point. Ten years ago the University of Illinois had in all its departments about 600 students, now it has 4,000. With the same rate of growth for another decade it would have in 1915 over 25,000 students. The college of agriculture in 1895 had less than a score of students, now it has over 400. With a population of, perhaps, one and one-quarter millions in the farm homes of the State 5,000 or even 10,000 students may soon be clamoring for admission to the college of agriculture of the University of Illinois, especially if its terms of admission are kept as liberal as at present.

No wonder President James is alarmed at such a prospect with the impossible burdens which it would impose on the president and the agricultural faculty. His remedy naturally is the raising of entrance requirements and the establishment in different parts of the State of secondary schools with agricultural courses. Such schools, individually maintained without great expense, might give the university properly prepared agricultural students and at the same time turn back directly to the farms of Illinois thousands of young men and women with an enthusiasm for country life and a hopeful outlook toward a progressive and profitable agriculture, because they had been brought into vital touch with the great movement for the application of science to agriculture and the domestic arts, and had obtained at the same time a better training in language, mathematics, science, history, music, and drawing than the common schools afford.

The trustees, presidents, and faculties of land-grant colleges generally would in my judgment do well to follow in the same line of thought and effort on this matter as is being pursued by President James and his associates, and I judge from what I have heard and observed of late at the land-grant colleges that many of them are either working or planning to work in this direction.

John Hamilton, of the Office of Experiment Stations, presented the following paper:

THE "OPEN DOOR" FOR THE LAND-GRANT COLLEGE—THE FARMERS.

THE LAND-GRANT COLLEGE—ITS COMMISSION.

Its commission is "*to teach.*" Teach whom? Teach what? Including military tactics, to teach the industrial classes such branches of learning as will educate them liberally and practically for the pursuit of agriculture in its various departments and of the mechanic arts.

After having adequately provided for instruction in these two classes of industrial pursuits, then if any funds derived from the land-grant act remain, or if the institution has funds from other sources, such funds may be used for the giving of instruction in "other scientific and classical studies" in order to fit men for the "professions" in life.

The supplemental Morrill bill of 1890 directs that the funds received under its provisions shall "be applied *only* to instruction in agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural, and economic science, *with special reference to their applications in the industries of life*, and to the facilities for such instruction."

This act not only cuts out all language studies except English, but it also emphasizes the important fact that such mathematical, physical, natural, and economic science studies as are taught shall be taught, not after the old traditional manner, but in an entirely new way, with "special reference to their applications to the *industries*." What industries?

The title of the bill indicates the "industries" intended to be included. It declares the purpose to be "to apply a portion of the proceeds of the public lands to the more complete endowment of the colleges *for the benefit of agriculture and the mechanic arts*." It does not say "and for the other industries and professions in life," but stops with the two great industries that were to be the leading objects of education, as indicated in the act of 1862.

This act of 1890, coming as it does twenty-eight years after the founding of the land-grant colleges, is in the nature of a definition or declaration of purpose of the act to which it is a supplement. Some of the colleges had used the funds of the original grant to teach mathematics, physical, natural, and economic science, together with language studies, in a way that directed men into professional life, or at least that did not lead them into industrial pursuits. This act of 1890 distinctly prohibits such use of its funds, and by inference applies the same restriction to the original act, at least until the two leading industries—"agriculture" and the "mechanic arts"—have been fully provided for.

But why refer to this that ought to be, and doubtless is, familiar to every land-grant college officer? Simply by way of reminder of the fact that a "door," wide and open to agriculture, was provided for by both of these national laws, and was directed to be swung in the front portal of every institution that accepted the grants which these two acts of Congress bestowed.

That there is need of such a reminder is evident from the practice of some of the land-grant colleges in their distribution of the funds received under the Morrill Act, as shown in their reports to the Bureau of Education of the United States. The reports for the year ended June 30, 1903, the last published, show that the colleges that year varied in the amount which they assigned to agriculture out of the $25,000 received under the Morrill Act from less than $5 in one instance to over $14,000 in another. The general average given for agriculture out of this fund by all of the institutions was 16 per cent and for mechanic arts 28 per cent. By omitting four institutions giving the highest amount to agriculture, the percentage assigned to agriculture by the remainder is reduced to 13.35, and if five of the next highest are likewise omitted the percentage will be but 11.6.

By taking twelve institutions appropriating the least to agriculture, representing an income that year from the Morrill fund of $289,286.76, the amount given to agriculture is 3.75 per cent and 31.75 per cent to mechanic arts. On the other hand, taking the four highest in appropriation to agriculture that year, we have, in a total of $104,494.16 received under the Morrill Act, 44.9 per cent appropriated to agriculture and 20 per cent to mechanic arts. If, therefore, the apportionment of this fund is at all indicative of the distribution of that of the act of 1862, then we have exhibited the varied interpretations which the land-grant colleges place upon the language of the two acts of Congress so far as making education in agriculture their leading object is concerned. In short, we have their view of their obligations to open the door to agriculture as agriculture is now defined by the Bureau of Education of the United States, which includes agriculture, horticulture, forestry, agronomy, animal husbandry, dairying, veterinary science, poultry industry, and apiculture.

We also have their view as to the relative importance of education in agriculture as compared with education in the mechanic arts. That there is wide divergence of view in these respects among those whose duty it is to administer this trust is thus manifest. As a consequence we find that the door of agriculture in some of the land-grant institutions is out in front and is flung open wide, while in others, as the figures show, it is found in rear and is set ajar just far enough to provide for moderate ventilation without causing a draft.

THE LAND-GRANT COLLEGE—ITS OPPORTUNITY.

The land-grant college of to-day stands at an "open door." It has been let down in the midst of 28,000,000 of agricultural people. The educational needs of farmers were never greater than they are to-day. The power to aid stored up in the land-grant institutions was never better adapted to meet country needs than it is to-day. The barriers that once divided science from practice are almost completely broken down. The gates of agriculture, once barred by prejudice against college training, are now wide open.

What more can the land-grant college wish? An "open door" is all that the gospel message has ever asked. "Free entry" is all that legitimate commerce seeks. "Opportunity" is the only advantage that a capable man desires.

Applying the truth that opportunity carries with it corresponding responsibility, the land-grant colleges stand in the midst of the American people responsible for their agricultural salvation. They were created for their deliverance; they were endowed for this; they ought to be officered and equipped and administered for this end.

However much they may have done in the past or may in the future do for the aid and elevation of men in their several pursuits and professions in life, they have signally failed of the main purpose of their creation if they have neglected to do for farming people not all that farming people need but all that modern knowledge in agricultural science has made it possible for them to do.

What shall they do for farmers? From the "open door" of opportunity there lie in plain view three great fields, for whose cultivation the land-grant college was designed.

FIELD I.—THE COLLEGE CLASS ROOM.

(a) *The four-year course.*—For the education of young men and young women for teachers of agriculture, for scientific investigators in agricultural subjects, and for experts to take charge of agricultural enterprises requiring special skill and thorough scientific training—a course the equal in culture value and discipline of the mental powers of any other course.

(b) *The short courses.*—These for students whose circumstances prevent their remaining in college for the full four-year term, and yet who can leave home for portions of one, two, or three years to engage in agricultural study along special lines.

(c) *Postgraduate courses.*—These for advanced study and to qualify for agricultural experimentation and research.

FIELD II.—COLLEGE EXTENSION WORK.

This embraces—

(a) The correspondence school of agriculture.
(b) The farmers' institute.
(c) The movable school of agriculture.
(d) The practice farm.

The obligation of the land-grant college is not restricted to the comparatively few who come to its class rooms, who live within its walls. The great mass of agricultural people live outside. Of what value is an "open door" to a man an hundred miles away chained to his work unless out of that door there come to him messengers of help?

The command to these institutions is to "teach." They have fixed location, but their commission to give instruction is not bounded by classroom walls. They were founded to "promote the liberal and practical education of the industrial classes." Where are these classes? For the most part out at work.

In the past the land-grant colleges have come to the assistance of farmers by fitting their sons in their class rooms for teaching and for pursuing agriculture as a calling, and by equipping them as investigators and expert scientists for service in the agricultural experiment stations and in the National Department of Agriculture. The "open door" to-day looks out upon a much wider field. It extends this obligation to giving aid to the farmer himself. The colleges have recognized this obligation. They have equipped and are conducting correspondence schools and reading courses in agriculture, and they are sending out specialists to give instruction in the institutes.

The correspondence school.—The correspondence school and the reading course in agriculture have benefited many who otherwise would have had little opportunity for self-improvement. They have prepared a literature specially adapted for the farmers' use, and through the selected studies which they have prescribed thousands have been brought to a better understanding of the possibilities of agriculture and have been fitted for its pursuit to an extent far beyond that which would have been possible without this aid. Valuable as they are they fail to arouse the enthusiasm that comes from personal contact with the living teacher.

The farmers' institute.—The farmers' institute has more than any other been the agency through which country people have been brought in contact with college life and college men. What has this intercourse between the college teacher and the everyday worker on the farm accomplished? It has filled the halls of many of these institutions with country youth. It has broken down once for all the barrier that existed between science and this industry, between the thinker in his study and the worker in the field, and has brought both to respect instead of despise or distrust each other. It has begotten between the practical worker on the farm and the investigator and teacher of the experiment station and the college appreciation, a fraternity of feeling and active cooperation, that no educational institution in any other age has been able to effect.

In 27 States and Territories the institutes are wholly controlled by the agricultural colleges and experiment stations. Nine hundred and ninety-two lecturers were regularly employed by the State institute directors for giving instruction during the year ended June 30, 1905. Of this number the faculties of the land-grant colleges and the staffs of the experiment stations furnished 366, who contributed that year 2,646 days of their time to institute teaching. About 1,000,000 persons, chiefly farmers, were met and instructed in the institutes.

Was a wider door of opportunity ever opened to any other set of educational institutions than this which the farmers' institute presents? A door that opens out to a field altogether unoccupied and boundless in its possibilities.

Institute instruction, as it has been given, is however but the kindergarten of what is yet to come. The institutes have shown farming people that there is a large amount of valuable information in existence that would be serviceable to them if they had it, and they have demonstrated that it is entirely feasible to impart scientific information to practical farmers who have never had the advantage of scientific training.

The institute lecture heretofore has been in the nature of a sample of the subject. Not a full presentation, but only a minute portion of the great field that the subject covers. The methods used may be likened to those practiced by manufacturing establishments in their sending out representatives with samples of their goods to exhibit before the purchasing public. The merchant examines the sample, is satisfied as to its quality and adaptability to his trade, sends in an order. In the institute the lecture, as a sample of the subject, has been presented. The hearer is satisfied with the sample; is assured that a large quantity of similar information is in store. He accordingly, like the merchant, desires that he be furnished with an amount sufficient to meet his needs.

At this point the present system fails. As at present organized it can not meet this need. It fails both for lack of time, and from the unwillingness or inability of any considerable number of persons in any community to devote themselves to the study of a subject for a period long enough to become thoroughly instructed.

The movable school.—To meet these conditions and overcome the difficulties which they occasion, a system of "movable schools" has been devised. The plan provides for organizing, in various communities, classes of not less than 8 nor more than 15, the members subscribing to an agreement to attend a course of lectures upon some agricultural subject, continuing for from two to four weeks as the case may be, and to perform such demonstration and practice work as the course requires. The school is intended to be equipped with all of the apparatus needed for instruction in the specialty, and be taught by one or at most by two experts who give instruction upon a single subject.

If the topic, for instance, be "poultry" the entire course would be devoted to that study, pursuing a graded outline, beginning with the elementary principles of poultry rearing, and continuing by progressive steps until its completion, each lecture to be accompanied by a practicum lasting from an hour to an hour and a half, in which all of the students would participate.

Upon the completion of such a course each student would not only have had opportunity to acquire theoretical knowledge of the subject, but would also have actually performed such operations as the practical producer of the product must conduct. The instructor would be expected to visit at least one of his scholars each day, consulting with regard to the improvement of the conditions that exist at his home in the direction in which the instruction is given.

Upon the completion of the course the teacher would move to another center and there conduct a similar school. By this method there would be left in each farming district where the school is held at least ten or twelve persons fitted for doing the things that had been taught, forming a corps of resident practical demonstrators and instructors whose influence, example, and teaching would be constantly at work for the betterment of those among whom they live. These schools can be varied and multiplied according to the needs of the various communities.

In this way continuous instruction could be given throughout the year, and permanent occupation be provided for skilled specialists, to whom there would be opened up a career in institute work that does not now exist.

The practice farm.—The graduates in agriculture in the land-grant colleges lack qualification for taking charge of important agricultural interests by reason of their inexperience in business methods, in the control of labor, and in conducting the details of successful farming. Facilities for developing these qualities, essential in successful agriculture, the colleges now fail to furnish.

If each land-grant institution had under its control from five to twenty or more farms of from 10 to 50 acres each, distributed throughout the State, equipped for carrying on the various operations of agriculture, and would place them in charge of her graduate agricultural students that they might gain experience in the practical operations of farming, a much needed and valuable addition to the present course in agricultural education would be supplied.

The graduates in charge would be under the general direction of the officers of the institution, and would be expected to continue for two or three years, serving at a nominal salary, keeping the books, directing the labor, planning new work, conducting all of the operations, and reporting results.

The farms could be specialized to any extent. One might be devoted to dairying in one or all its branches, another to the breeding or feeding of stock, another to poultry rearing, another to market gardening or to greenhouse products or floriculture, another to horticulture, and some to general farming.

Such practice farms would not only fit agricultural graduates for entering upon their own farms and conducting them successfully, but would also provide a supply of experienced managers for experiment and demonstration work and for the oversight of large estates.

Is it not the obvious duty of the land-grant colleges to occupy these fields in college extension work by organizing their faculties of instruction and otherwise equipping themselves for properly conducting correspondence courses, for engaging more fully in the farmers' institute work, for conducting movable schools of agriculture, and for establishing practice farms, utilizing these agencies for reaching and assisting the great agricultural class, whose liberal and practical education in agriculture they have pledged themselves to promote?

FIELD III.—NORMAL SCHOOLS OF AGRICULTURE.

Experts are needed for:

(a) Farmers' institute instructors.
(b) Teachers in movable schools of agriculture.
(c) Field demonstration work.

There are three sources of supply:

(1) From the membership of the faculties of the agricultural colleges and the experiment station staffs.

(2) From a special force of experts employed by the agricultural colleges as field men, who are also itinerant instructors in agriculture.

(3) From among capable farmers who have notably succeeded in at least one important department of agriculture.

Teachers of the first two classes will necessarily almost all be college-trained men, graduates who have taken the full 4-year course and have had experience as teachers, experimenters, or practical demonstrators in agriculture. The number of such men available for agricultural extension work will always be inadequate. But whether many or few, a normal school would be helpful in training them in the art of presentation and in extension methods.

The remaining resource is to secure from among the most intelligent, capable, and successful farmers such as show aptitude for teaching and give them additional training in the specialty that they have pursued. For this normal schools of agriculture ought to be provided.

A set of normal courses, to continue for several weeks each year, arranged to cover the specialties that extension work in agricultural education is called upon to teach, should be constructed, and faculties composed of expert specialists should be engaged to give instruction. By confining the attention of each normal student to the study of the particular subject that he expects to teach in the farmers' institute much might be accomplished in a reasonable time. A 16-weeks' course, giving 3 hours each day to lectures on a specialty, 3 hours to practical work, 2 hours for reference work in the library and for special reading, and 1 hour for lecture upon some general subject, would amount to 864 hours, all devoted to instruction in the student's specialty, except the 96 hours given to hearing lectures upon general subjects.

Experiments made show that no single State is able at present to establish, equip, and properly conduct a normal school such as extension work in agricultural education demands for the education of its lecturers.

The first practical difficulty is that the number of scholars in any one State entering such a school will be comparatively small, rendering it almost impossible, if they are divided into classes according to their several specialties, to have classes of sufficient size to warrant the expense. The second is that most of the agricultural colleges are not yet sufficiently equipped in their teaching force of experts to do more than cover a quite limited range of topics. The third and insurmountable difficulty is that no one institution can afford to give the use of its teaching force for the length of time needed to make a course effective. If, however, several States were to unite in a normal school to be held at different institutions each year, equipped with a teaching force contributed by each, the difficulties mentioned would be largely overcome.

Interstate normal schools for the instruction of specialists in agricultural extension work, the farmers' institute, the movable school, the practice farm, and the demonstration field would add immensely to the service that the land-grant colleges are now rendering, and would make possible the extension of agricultural instruction to an unlimited degree.

In conclusion, Congress intended to swing wide the door of agricultural education to farming people. If the land-grant colleges will equip themselves and occupy the entire field that agriculture offers for their effort; if they will take advantage of the educational opportunities in aid of agriculture that lie before them, they will do no injustice to any other interest that the two acts of Congress require them to protect, and they will be but fulfilling their obligations to the farming people of the United States.

C. R. Van Hise, of Wisconsin. I desire to say a word or two in discussion of one of the papers which has been presented, namely, that by President Kerr, of the Agricultural College of Utah. It seems to me that he has outlined what is desirable in those cases where there is a subdivision of the university effort within the State. But I believe that if the statements which President Kerr has made are carried to their logical conclusion, and if they are measured in the light of actual development, but one conclusion can follow where this subdivision exists, namely, that there will be two or three institutions in the State in which both liberal education and practical education are given. There is no such thing as teaching practical education and application of science or the application of knowledge to life, except you base that work upon a broad foundation of pure knowledge. Therefore, one agricultural college after another has been obliged to introduce history, political science, English, or modern languages, and pure sciences in their courses in order to properly teach agriculture. If agriculture is so taught that it is more than manual training, this can not be avoided. On the other hand, the university can not exist in the realm of pure knowledge apart from practical effect. That makes it too theoretical an institution, and too far apart from the life of our people to win their support. The university feature which exists must at various points touch the people, and touch them closely, and therefore the university has superimposed upon these literary courses, upon pure knowledge, various lines of the applications of science, of knowledge, law, medicine, engineering, as well as other applications. Therefore it is impossible to avoid overlapping. Those States which have started out to maintain two or three institutions have started out to maintain an expensive system, but if they maintain it efficiently, if the system gives them the results which they hope to get, they will be obliged to pay the cost, and they must do these things.

It is not necessary that the entire realm of pure knowledge be covered in a college of agriculture. It is not necessary that the ancient languages, that the oriental languages, that biblical literature, that archaeology, and those subjects be taken up. It is not necessary in the universities to take up all the fields of applied science, but chemistry, physics, botany, English, political economy, political science, to some extent, and history must be factors of both institutions, and the States that try to maintain the two colleges must pay for that duplication. There is no other way. They must pay for it in laboratories and equipment, and to some extent in men. It is, however, not necessary for each college to do all the work in the applications of science to life. Naturally the university does not cover the field of agriculture. In no case, so far as I know, does the agricultural college attempt to cover the fields of law and medicine. There is the debatable ground of engineering in all its branches, which is distributed between the two, and it should be distributed between the two, as President Kerr has said, in the weaker States, but which in the stronger States will be inevitably developed in both.

I make these remarks because this problem is before some of the Western States. It is still a live issue in some of them. It is my judgment, and most deeply seated, that all States which are yet able to adopt the policy of concentration should do it, because the expense is so great that it is impossible to do the best and have duplication. In those States in which the policy of subdivision has been adopted the best effort ought to be made by the two or three institutions to harmoniously work together for the best interests of the State.

With an expression of thanks to the officers of the section and to those who contributed to the programme, the section adjourned sine die.

SECTION ON EXPERIMENT STATION WORK.

Afternoon Session, Tuesday, November 14, 1905.

The section convened at 3.10 o'clock p. m., the chairman, H. J. Patterson, presiding.

H. J. Wheeler, of Rhode Island, presented the following report:

Report of Committee on Agricultural Federation.

Your committee begs to report that during the past winter a letter was sent to every director in the United States urging him to take such steps as might be necessary to bring about a federation of his State agricultural organizations. It was not expected that the directors should take a directly active part in the promotion of the federations.

The chief drawback to the federation idea in the South and West was found to be a lack of organizations to federate, and in some instances a lack of ready means of railway communication. In two or three States federations were already in existence, and in others they have been formed as a result of this effort.

The following is a list of the States in which federations exist, with the names and addresses of the secretaries:

Name of State.	Name and address of secretary.
Maryland	Asa B. Gardiner, jr., Baltimore, Md., 514 North Calvert street.
New Jersey	Franklin Dye, Trenton, N. J.
New York	T. B. Wilson, Halls Corners, N. Y.
Pennsylvania	H. P. Armsby, State College, Center County, Pa.
Rhode Island	H. J. Wheeler, Kingston, R. I.
Iowa	George A. Wells, Des Moines, Iowa.
Michigan	L. Whitney Watkins, Manchester, Mich.
Texas	J. W. Carson, College Station, Tex.
West Virginia	

The following brief statement sets forth the existing situation in each of the other States as it has been reported to date:

Alabama	Expression favorable.
Arizona	No reply.
Arkansas	No reply.
California	No reply.
Colorado	Favorable, planning for a federation.
Connecticut	Unfavorable to federating.
Delaware	No reply.
Florida	Favorable.
Georgia	Favorable.
Idaho	Favorable to the idea.
Illinois	Unfavorable to federating at present.
Indiana	No reply.
Kansas	Not favorable at present.
Kentucky	No organizations of farmers exist at present, but they are being agitated.
Louisiana	Favorable.
Maine	Favorable, but difficulties to be overcome.
Massachusetts	Unfavorable report.

Minnesota	Unfavorable.
Mississippi	No reply.
Missouri	Favorable; some progress in federating already made.
Montana	May attempt federation the coming winter.
Nebraska	No definite report.
Nevada	Impossible for a year or two.
New Hampshire	Unfavorable at outset, but showing signs of a change of attitude.
New Mexico	No reply.
North Carolina	Action in concert, but no official federation at present.
North Dakota	No farmers' organizations, but favorable to federation.
Ohio	Favorable.
Oklahoma	A practical though not official federation at present.
Oregon	Federation not needed at present.
South Carolina	Indefinite response.
South Dakota	Favorable.
Tennessee	Matter under investigation.
Utah	No reply.
Vermont	Nothing has been done as yet.
Virginia	Being organized at present.
Washington	Federation under way at present.
Wisconsin	Need not felt at present.
Wyoming	No organizations to federate.

While your committee can not report great success in its work, it is evident that a fair amount has been accomplished already in the past year, and that if followed up persistently most of the States may perhaps be led to establish federations.

H. J. Wheeler,
Chas. D. Woods,
H. J. Patterson,
Committee.

The report was accepted and the committee continued.

Soil Fertility in Relation to Permanent Agriculture.

C. G. Hopkins, of Illinois, read the following paper upon this subject:

If the combined efforts of the United States Department of Agriculture and the various State experiment stations result in the discovery, and the ultimate adoption by farmers and landowners, of profitable systems of permanent agriculture, it must forever stand as the greatest achievement in American industry and as the surest guaranty of permanent national prosperity.

Several soil experiment fields are being conducted on the various types of soil in the different sections of Illinois by the Illinois State Experiment Station. At a recent conference of the farmers and landowners upon whose farms these experiment fields are located, the statement was made by one of the gentlemen present that when he was born there was not a mile of railroad in the United States. He was born only twenty-five years after Washington died. These statements help us to realize that America, as a nation, is very young.

This same gentleman, Col. N. B. Morrison, of southern Illinois, stated that he had not only seen the development of the entire American railroad system, but that he had also seen the essential ruin of agricultural lands by regions in these United States.

Are there tracts of land in this new country whose productive capacity has been reduced?

Are there fields in Virginia which once grew great crops of corn and tobacco but which are now abandoned and disowned, so that no man pays taxes upon them?

Are there farms in the famous Mohawk Valley which can now be purchased for less than the farm buildings once cost?

Are there agricultural lands in the Western Reserve which were sold half a century ago for more than $100 an acre, and which can now be bought for less than $50?

Are there farms in Indiana and in southern Illinois whose cash value is less to-day than thirty years ago?

Are those wonderful wheat lands of Minnesota and the Dakotas, where I gathered the buffalo bones from before the plow that turned the virgin sod—are they producing smaller crops of wheat than twenty years ago?

To all of these questions men who know the facts and conditions have answered yes.

In this convention of representatives from American agricultural colleges and experiment stations, it seems not inappropriate even to remind ourselves that, without agriculture, America is nothing.

The forest and the earth supply the timber, the stone, and the metal to build and equip railroad and factory and the fuel to operate mill and locomotive, but directly or indirectly these great industries are absolutely dependent upon agriculture for their continued existence. Without agriculture the forest trees would be left to grow, the coal and iron would remain in the earth, the cities and the railroads would be abandoned, and the people must return to hunting and fishing, the industries which preceded agriculture.

It is true that an intensive agriculture consisting of dairying, fruit growing, and truck farming may be supported by large cities, which, however, derive their support largely from the trade and commerce related to the more extensive agriculture of newer regions.

It is also true that the farm manure produced in Europe from the shiploads of corn and other products from American farms, supplemented by commercial fertilizers, made in large part from American phosphate rock, will materially assist in maintaining the agriculture of some European countries.

We must bear in mind, however, that the United States can never hope to draw upon her colonies nor upon foreign countries for unlimited quantities of food and fertilizer; and even now we must recognize the fact of a decreasing productive capacity of large areas of the best lands in our richest agricultural States.

Are there possible systems of profitable permanent agriculture of unlimited application?

The dairy system of farming, in which only butter is sold from the farm, maintains the fertility of the soil if all other products or residues are properly returned to the land; but the application of this system is exceedingly limited, because the world can not live on butter alone.

If milk or meat is sold and concentrated feeds are purchased, we can not only maintain, but increase, the fertility of the soil; but all farmers can not purchase unlimited quantities of concentrated feeds from their neighbors and make use of the manures thus afforded upon their own farms, nor will the world live upon meat and dairy products only.

Probably 80 per cent of the farmers of the United States sell wheat or corn or cotton, and probably they always will; and let no man presume that he has found permanent salvation for American agriculture until he has provided some adequate means for the profitable maintenance of the productive capacity of those farms which are to supply the world with bread and clothing.

There is a system by which we can keep what we have, a system which may sometime be forced upon America as it has already forced itself upon such countries as China, a system which requires that every farm product be followed to its ultimate consumption and every residue brought back, a system which requires the country women of China to carry their produce to market and exchange it in part for the night soil of the village, which has been carefully saved for its fertility value and which must be carried back to the farm.

May this necessity be far removed from the country of whose fertility we are the guardians!

In considering the question of permanent agriculture, I am not unmindful of the fundamental principle announced by the Bureau of Soils, namely, that "practically all soils contain sufficient plant food for good crop yields," and that "this supply will be indefinitely maintained," toward the demonstration of which some contributions are being made by means of carbon black and other nonnutrient materials in twenty-day pot culture experiments; but this assertion has not yet been proved, and we still feel obliged to accept the more conclusive evidence of such exact sciences as chemistry and mathematics and the scientific experiments of half a century and the practical experience of ages, regarding the possible depletion of the fertility of soils.

It is of course true, in theory, that while the length of a quarter section of land is one-half mile and its width is one-half mile, its depth is 4,000 miles. In practice, however, we are limited to a few feet in depth. There is a depth, varying with different conditions, from below which crops draw less plant food than is lost from above in surface and subdrainage. It is not yet known to what depth we should measure our stock of plant food, but this we know: That the process of oxidation, including nitrification, and of fermentation and decompositon, by means of which plant food is liberated and made available for plants, is limited almost exclusively to a few inches of surface soil.

While our interest in the physical composition should be measured by feet in depth of soil, our interest in the chemical composition may be measured by inches. Given 6 or 8 feet of soil of perfect physical composition, capable of absorbing and retaining moisture to be delivered by capillary action to the growing plants as needed, with 6 or 8 inches of surface soil of perfect chemical composition, and large crops are assured; but of little value is a rich subsoil overlain by a worn-out surface.

The argument is made that immeasurable quantities of plant food are brought from unknown depths by the capillary rise of the soil solution. Considering the facts that rainfall far exceeds evaporation in most humid countries, that subdrainage waters always carry away some plant food, and that old leached soils contain much lower percentages of lime and plant food elements than are contained in similarly formed soils of more recent origin, we conclude that we must not depend upon the supply of plant food being maintained by the rise of the soil solution. As an average of thirteen years at the Rothamsted Experiment Station, the annual loss of nitrogen in the drainage water from a 20-inch gauge, containing 20 inches of soil, was 37 pounds per acre, while from a 60-inch gauge, containing 60 inches of soil, the loss was 36 pounds of nitrogen per acre, or 1 pound less from the 60-inch than from the 20-inch gauge, thus showing that there is a loss and that the loss is from the surface soil.

Another argument which some hold to make ample provision for the indefinite maintenance of the fertility of the soil is the fact that the soil is constantly being mixed to unknown depths by ants, earthworms, crawfish, and other agents. The fact that we have soil and subsoil which are markedly different is sufficient evidence that this mixing process is very limited. Indeed, the composition of the subsurface soil lying immediately below the plow line is usually appreciably different from that of the plowed surface, and not infrequently we find at a depth of 8 or 10 inches a stratum differing markedly in character from the surface soil.

With due respect to Darwin and to his more ardent supporters of this theory, we must conclude that these agents could not be depended upon to permanently maintain the fertility of the surface soil, even if their activities extended to inexhaustible supplies of plant food.

The truly fundamental plant-food questions which probably deserve the most serious consideration are as follows:

(1) To what depth do plants feed significantly in practical crop rotations?

(2) What is the total stock of plant food in the soil to this depth?

(3) How rapidly by practical methods can this plant food be made available?

(4) When necessary, in order to insure the production of large crop yields, how can we most economically supplement the plant food which can profitably be liberated from the soil?

Investigations are in progress in Illinois to determine the depths to which different plants feed under varying conditions, and because of the very great importance of this subject I take the liberty to urge that other experiment stations assist in solving this problem, especially for the soils and crops of local importance, and to suggest that the assistance of the National Bureau of Soils in this line of investigation would be deeply appreciated and probably of great value.

As a rule we all prefer to report upon the actual results of investigations rather than upon the plans or methods of investigations in progress, but it seems not inappropriate, considering the needs and possibilities of solution, to describe one of the methods by which we are attacking this problem.

We take a given soil and enrich it to a certain depth, say 7 inches. In another pot or plat we enrich the second 7 inches of soil; that is, between 7 and 14 inches in depth, and in another pot or plat we enrich the entire 14 inches in depth, using twice the quantity of plant food required for a 7-inch stratum. By growing plants in these soils we are thus able to determine the influence upon plant growth of a rich substratum, not only when the surface soil is poor but also when it, too, has been enriched. By varying the depths and strata to which plant food is applied, the amounts and kinds of plant food added, and the kinds of crops and soils used, the investigation is made to cover a variety of conditions.

Regarding the second question, we do not know as yet what depth of soil should be used in computations relating to the elements of soil fertility, but from what meager data we have thus far obtained I question if, in our common soils and with our common crops, we can draw plant food in significant amounts from depths below 18 inches. In most soils with which I am familiar it has not been found profitable to plow deeper than 7 inches, and because of this I wish first to consider the total stock of plant food in the surface 7 inches of soil; and because I have less knowledge of soil conditions elsewhere I shall confine myself mainly to Illinois soils in this discussion.

It should be understood, however, that Illinois soils are probably as rich as those of other States with similar climate and latitude. This is strongly indicated by the Government statistics relating to the corn crop. About 1,200,000,000 bushels of corn (one-half of the corn crop of the United States and more than one-third the total corn crop of the world) are produced annually in the five States—Illinois, Iowa, Nebraska, Kansas, and Missouri. The State of Illinois, with one-sixth of the combined area of these five States, produces one fourth of this corn. Illinois not only produces more corn than any other single State, but according to the Government averages for the past ten years the yield per acre in Illinois is from 2 to 13 bushels higher than in the other corn-belt States.

Five great soil areas comprise the larger part of the Illinois corn belt. These areas are known as the Middle Illinois Glaciation, the Upper Illinois Glaciation, the Pre-Iowan Glaciation, the Early Wisconsin Glaciation, and the Late Wisconsin Glaciation. More than one-half of the State of Illinois is included in these five soil areas. The principal types of soil in each of these great areas have been carefully investigated, and I shall consider here an average which represents the commonest soil in the Illinois corn belt—soil which in normal seasons produces 60 bushels of corn, 60 bushels of oats, and 30 bushels of wheat per acre, without the use of manure or fertilizers. In discussing the average composition of this soil I shall not consider the element nitrogen, except to say that we do not and can not profitably raise corn on commercial nitrogen, and to remind us that, at commercial prices, there is more than $10,000,000 worth of nitrogen resting on every acre of the earth's surface. Furthermore, there is an actual profit in raising such crops as clover, stock peas, soy beans, and alfalfa for their own value, aside from the value of the nitrogen which they fix. The general farmer may sometimes buy water, but he ought never to buy nitrogen. Aside from its use in intensive farming, as on high-priced land near large cities, the element nitrogen has no justified commercial value.

I wish to consider the phosphorus and the potassium in this Illinois corn-belt soil:

In an acre of this soil to a depth of 7 inches, which is estimated to weigh 2,000,000 pounds, there are less than 1,200 pounds of phosphorus and more than 36,000 pounds of potassium. If we could draw upon this plant food for 100 bushels of corn each year, the phosphorus would be entirely exhausted in less time than is measured by the life of one such man as Col. N. B. Morrison. The second 7 inches of soil contains less phosphate than the first, for our rich, loamy soils contain in the surface stratum some organic phosphorus, a part of which has certainly been brought from the second 7 inches by the vegetation which has grown during past centuries.

The 36,000 pounds of potassium contained in the first 7 inches of soil are sufficient to supply potassium for a 100-bushel crop of corn each year from the birth of Christ until the present time, assuming that the grain only is sold from the farm. In the second 7-inch stratum the supply of total potassium is sufficient for another 1900 years. If the surface of the soil is washed away so that the general level of the cultivated land is lowered at the rate of 1 inch in 300 years, then our supply of potassium is absolutely permanent for a system of practical agriculture of unlimited application.

Regarding the third question, it should be noted that much ignorant and unjust criticism has been offered because the chemist is not able to determine at any given time how much available plant food the soil contains and how much the next crop will be able to secure from the soil, and because different chemists have employed different methods in trying to get some measure of the plant food which is likely to become available some time, but have not found any one method which gives all of the information desired.

The soil-fertility question in which mankind is most interested is not, How much so-called available plant food does the soil contain at any given moment? but rather, How much total plant food does the soil contain and how can we best make it available? By chemical methods, and by no other, can we ascertain the total stock of plant food in the soil to any given depth. Chemistry may also aid in a study of the probable rate of availability. Thus, if I may offer an illustration, we find that the ordinary brown silt loam soil of the Illinois corn belt in the Early Wisconsin Glaciation contains in the surface soil twice as much potassium soluble in hydrochloric acid as is contained in the gray silt loam soil of the Illinois wheat belt in the older Lower Illinois Glaciation, although the total potassium content of the soils in these two great areas shows no such proportionate difference. Thus, chemical analysis plainly indicates that potassium in the one soil will be made available much more readily than in the other; and in actual practice we find that the application of commercial potassium to the one soil produces no increase in the corn crop, whereas when applied to the other soil potassium increases the yield of corn by 50 per cent, amounting to 20 or 30 bushels increase per acre under favorable conditions.

How to liberate from the soil's inexhaustible supply sufficient potassium to supplement that which can be returned in farm manure, and thus meet the needs of maximum profitable crop yields, is one of the problems to be solved in a system of permanent agriculture. We are still hoping that this may be accomplished by means of decaying organic matter, and to this end we are using not only all available farm manure but also green manures, especially nitrogenous green manures from legume crops.

The fourth question relates to the addition of commercial plant food, when necessary, to supplement that which can profitably be liberated from the soil's supply.

The truck farmers of New Jersey will do well to follow the teachings and experiments of their agricultural experiment station and make liberal use of commercial nitrogen, and thus hasten the maturity, improve the quality, and increase the yield and value of their market-garden crops, even to the extent of $180 per acre, as Director Voorhees has done at New Brunswick; but for the general farmers of America to try to raise 2,500,000,000 bushels of corn with 16-cent nitrogen, at an annual cost of $400,000,000, is not only absurd but it would be impossible, for there is no adequate commercial source for such supplies of nitrogen. All of the information thus far obtained justifies the conclusion that for the general farmer who practices a suitable rotation of crops and makes proper use of legume catch crops and of manure which may be produced on the farm the purchase of commercial nitrogen is both unnecessary and unprofitable. Well-inoculated legume plants will thrive even in soils devoid of nitrogen if they are well provided with lime and the mineral elements of plant food. There is no great nitrogen problem, for it was solved by Hellriegel and Atwater and others more than fifteen years ago.

On some soils of limited extent, as the peaty swamp lands and some sandy lands, applications of potassium must be made. This may be in the form of farm manure produced from crops grown on lands rich in potassium, or commercial potassium salts from the German mines may be used; but on our normal agricultural lands of glacial origin, with a supply of total potassium in the plowed soil sufficient for large crops of grain for twenty centuries and with subsurface and subsoil equally rich in potassium, the corn and wheat belt has no great potassium problem except to liberate that element as needed from the soil. I can not speak for the cotton-belt soils nor for those which are required to grow tobacco, but it seems noteworthy that by the ultimate analysis of 48 samples of Maryland subsoils, comprising 12 different soil formations, Veitch found that the general average composition of normal soils in these 12 formations[a] shows less than 1,200 pounds of phosphorus and more than 33,000 pounds of potassium per acre for a 7-inch stratum assumed to weigh 2,000,000 pounds. This agrees very closely with the average composition of Illinois surface soils.

So far as can be ascertained from the analytical data at hand and from the use of commercial plant food in agricultural practice, the more common glacial loessial, and residual soils of the United States contain an immense store of total potassium and a very limited amount of phosphorus. There are of course notable exceptions, such as the famous "Bluegrass regions" of Kentucky and Tennessee, which are thought to bear some relation to the natural phosphate deposits in that section, where some soils exceedingly rich in phosphorus are found. Attention is called to the fact that three-fourths of the potassium required for a crop of corn or wheat remains in the stalks or straw used as feed or bedding, and when the grain also is fed to animals practically all of the potassium is recovered in the liquid and solid manure.

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[a] Four other formations, including sandy truck soils and sand and other barren soils reported by Veitch, are omitted from this average.

If there is a single key to America's permanent prosperity it is the element phosphorus.

Phosphorus is the element of plant food which already limits the productive capacity of at least 80 per cent of our best agricultural soils, judging from all available information. Fifty-one crops of corn yielding 100 bushels of grain and 3 tons of stover would require the total phosphorus contained in our average corn-belt soil to a depth of 7 inches. Three-fourths of this phosphorus remains in the grain, and thus leaves the farm if the grain is sold. If the grain is fed to meat-producing or milk-producing animals, one-fourth of the phosphorus in the food consumed must leave the farm in the animal products, butter alone excepted.

How are we permanently to maintain in American soils a sufficient supply of phosphorus to insure profitable crop yields? Is not this the greatest question that now confronts the farmer or the experiment station or the American nation?

We obtain phosphorus from basic slag in excellent form, but the total amount of phosphatic slag produced or likely to be produced in this country is almost insignificant compared with present or future needs.

The total supply of bone would be required to maintain the live-stock farms, even if it were all returned to the land from whence it came; but at the present time most of the bone produced in this country is used for other purposes than to fertilize the land. Steamed bone meal, which contains one-third more phosphorus than raw bone and sells at a lower price per ton, is, however, one of the most satisfactory forms of phosphorus for soil improvement.

The natural rock phosphate deposits of the United States, chiefly in South Carolina, Florida, and Tennessee, are believed to be among the most extensive in the world. They, too, like the fertility of American soils, were once thought to be inexhaustible, but now it is known that the visible supply of high-grade rock will be exhausted in less than fifty years if the present rate of increase in consumption continues.

More than 1,500,000 tons of this phosphate rock are annually removed from our deposits and more than 1,000,000 tons, or two-thirds of the entire product, are annually exported to foreign countries. The phosphorus contained in this annual export is sufficient for 1,500,000,000 bushels of corn, or half the annual corn crop of the world. Is not this exportation America's greatest crime against her own posterity? We can make bricks without straw but we can not grow corn or wheat or cotton without phosphorus.

And what is being done with the 500,000 tons of rock phosphate which is not exported? A ton of this raw rock, containing say 250 pounds of phosphorus (sufficient for 1,500 bushels of corn), which is worth about $4 at the mine and which can be delivered to Illinois farmers for about $8, is commonly mixed with a ton of sulphuric acid, thus making 2 tons of acid phosphate, containing 60 per cent of manufactured land plaster and only 125 pounds of phosphorus per ton. The acid phosphate can be purchased by the farmer for $16 a ton, or $30 for the same amount of phosphorus as is bought for $8 in the raw state; but as a rule 2 tons of acid phosphate are mixed with 2 tons of "filler" or "make-weight," usually containing a small amount of nitrogen and potassium, and thus we have 4 tons of so-called "complete fertilizer," the famous 2–8–2 goods,[a] containing 62½ pounds of phosphorus per ton, and selling at retail in the Central States for about $20 per ton, or $80 for the 4 tons of material containing no more phosphorus than 1 ton of raw rock which can be bought for $8.

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[a] By 2–8–2 goods is meant a "complete" fertilizer guaranteed to contain 2 per cent of ammonia, 8 per cent of "phosphoric acid," and 2 per cent of potash, or, on the basis of actual plant food elements, 1⅗ per cent of nitrogen, 3½ per cent of phosphorus, and 1⅗ per cent of potassium. For a 100-bushel crop of corn it would require 660 pounds of this fertilizer to supply the phosphorus, 4,300 pounds to supply the potassium, and 9,000 pounds to supply the nitrogen.

One commercial fertilizer company advertises fourteen brands essentially of this composition. This company advises farmers that "these brands will be best on almost any soil," and especially recommends them for corn, oats, wheat, and cotton. The average composition of these fourteen brands is as follows: Nitrogen, 1.5 per cent; phosphorus, 3.9 per cent; and potassium, 1.3 per cent. These amounts of nitrogen and potassium are too small to justify consideration by the consumer. If the phosphorus is worth 10 cents a pound, the average value of these fertilizers would be $7.80 a ton, although the same amount of phosphorus can be bought for $2.50.

Is it any wonder that farmers who use "complete fertilizer" can not afford to apply it in sufficient amounts to positively enrich their soils; that they must apply it for its effect on a single crop, and that they must depend upon the small amount of phosphorus added, together with that which the soil would naturally give up and that which the stimulating action of the land plaster forces the soil to liberate, in order to make a temporary profit? Is it any wonder that essential land ruin follows such a system?

Experiment-station men everywhere advise against the use of manufactured complete fertilizers, and some experiment-station men advise against the use of acid phosphate. Why should we pay $80 for 4 tons of "complete fertilizer," or even $30 for 2 tons of acid phosphate, for the same amount of phosphorus as we can buy for $8 in 1 ton of finely ground natural-rock phosphate?

Some will answer that the raw rock is not readily available. This is true, but it is also true that it is the business of the farmer to make it available by means of decaying organic matter, the same means by which he makes available the insoluble potassium and the raw-rock phosphate naturally contained in the soil.

As an American, as an investigator, and as a farmer, I thank Director Patterson, of Maryland, and Director Thorne, of Ohio, who planned systematic experiments, to cover many years, to ascertain whether finely ground natural rock phosphate could be made available by turning it under with decaying organic matter, such as farm manure or green manure from legume crops.

Before we had begun the general investigation of Illinois soils, Patterson had some good evidence that when turned under with crimson clover raw rock phosphate is as valuable as bone meal, and Thorne had demonstrated that when used in intimate connection with farm manure rock phosphate is much more profitable than acid phosphate, on the basis of money invested.

The Maryland station now has eleven years' records and the Ohio station has nine years' records in these investigations.

Some of the Illinois plat experiments in soil investigation have been conducted systematically for twenty-nine years, and probably furnish the longest continuous history of any such experiments in the United States, but the Illinois experiments with rock phosphate, although extensive in scope, were begun too recently to afford much data. It may be stated, however, that where we have used finely ground natural rock phosphate in direct comparison with equal money values of steamed bone meal, both being applied in connection with decaying organic matter, we have thus far obtained a larger average increase with the rock phosphate.

So far as I can learn, whoever has persistently tried the use of liberal amounts of finely ground rock phosphate, in connection with abundance of decaying organic matter, has obtained results beyond his expectations, while those who have tried 50 cents' worth of rock phosphate in comparison with two dollars' worth of acid phosphate, usually for a single year, and without any provision for decaying organic matter, have condemned the rock phosphate.

How long will American farmers continue to pay $80,000,000 a year for fertilizers containing less total phosphorus than we export to Europe for $4,000,000 received at the mine, and which for $8,000,000, or one-tenth of our present national fertilizer bill, could be delivered to our farmers in finely ground natural rock phosphate?

Two dollars an acre is not counted a large bill for complete fertilizers, but $2 an acre would pay for a ton of raw rock phosphate delivered in Illinois every four years, and this application would actually double the total phosphorus content of the plowed soil of the Illinois corn belt in twenty years' time.

This would provide a system of permanent agriculture, limited only by the limit of our natural phosphate deposits. We hope for the discovery of still greater deposits of phosphate rock; but unless such discoveries are made, we must use high-grade rock while it lasts; then we must use the lower grades, of which there are some large deposits; and finally we must work over the old dump piles, in order to store our lands with phosphorus; and then we must guard that supply, using it for the production of crops and returning it again to the land in every possible recoverable residue.

The American farmer is still prosperous on our new rich lands, and there is no need of any sensation, but there is need for sense and for the greatest possible simplicity, in order that the people whom we serve may understand.

Crop yields in bushels per acre of Bloomington soil experiment field, conducted by the University of Illinois.

[Prairie soil: Brown silt loam, Early Wisconsin Glaciation.]

Plant food applied.	1902, corn.	1903, corn.	1904, oats.	1905, wheat.
None	37	60	61	29
Nitrogen	35	60	70	31
Phosphorus	42	73	73	39
Potassium	38	56	63	33
Nitrogen, phosphorus	44	78	85	51
Nitrogen, potassium	40	59	66	30
Phosphorus, potassium	50	75	70	38
Nitrogen, phosphorus, potassium	53	81	91	52
Average gain for nitrogen	1	4	11	6
Average gain for phosphorus	10	18	15	14
Average gain for potassium	[a]6	0	0	1
Average gain for phosphorus when added to nitrogen	11	20	20	21
Value of this increase	$3.85	$7.00	$5.00	$14.70

[a] Steamed bone meal used on this field.

Approximate cost of 25 pounds of phosphorus.

In rock phosphate	$0.80
In steamed bone meal[a]	2.50
In acid phosphate	3.20
In complete fertilizer	8.00

I ask your attention to this tabular statement, which gives the actual crop yields obtained during the first four years on one of our regular soil-experiment fields in central Illinois on typical corn-belt soil.

Each plat is 2 by 16 rods, and contains exactly one-fifth acre. The results are given in bushels per acre. The plant-food elements applied per acre per annum are as follows:

Nitrogen, 100 pounds, at a cost of $16, in 700 pounds of dried blood, which is sufficient for less than a 70-bushel crop of corn.

Phosphorus, 25 pounds, at a cost of $2.50, in 200 pounds of steamed bone meal, which is sufficient for more than a 100-bushel crop of corn.

Potassium, 40 pounds, at a cost of $2.50, in 100 pounds of potassium sulphate, which is sufficient for less than a 60-bushel crop of corn.

As an average of all tests during the last three years, an investment of $16 in dried blood has yielded a gross return of $2.78; an investment of $2.50 in steamed bone meal has returned $6.62; and $2.50 invested in potassium sulphate has returned 23 cents.

During these three years we have applied 300 pounds of nitrogen. We have actually removed 287 pounds of nitrogen from our best-yielding plat—120 pounds in the corn, 83 pounds in the oats, and 84 pounds in the wheat—so that if there has been no loss of nitrogen from the soil by leaching, our account shows a gain of 13 pounds of nitrogen in the soil and a loss of $39.65 in money. Measured by the increase in crop yields on this soil, the actual value of the nitrogen, which costs 16 cents a pound, is less than 3 cents.

In the account with potassium we have applied 40 pounds a year, or 120 pounds in three years. From our best-yielding plat we removed 58 pounds in the corn, 59 pounds in the oats, and 59 pounds in the wheat, making a total of 176 pounds removed. In balancing this account we find two net losses, one amounting to 56 pounds of potassium from the soil, and the other $6.80 in money. Measured by the increase in crop yields, the potassium applied has been worth 0.6 cent a pound, or one-tenth of its cost, which was 6¼ cents.

In our phosphorus account we have applied 25 pounds a year, or 75 pounds in the three years. We have removed 19 pounds in the corn, 13 pounds in the oats, and 13 pounds in the wheat, and our balance shows two net gains—30 pounds of phosphorus in the soil and $12.35 in money. The phosphorus, which costs 10 cents a pound in steamed bone meal, has already returned 26½ cents a pound in increased crop yields, and 40 per cent of the phosphorus applied still remains in the soil.

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[a] Potassium is applied as a soluble corrosive salt which, like common salt, may sometimes act as a temporary stimulant and liberate some phosphorus or nitrogen from the soil.

In closing, I wish to emphasize the opinion of myself, and surely of you who have had longer experience, that no man is justified in drawing conclusions from one year's work with pot cultures or field experiments; and to call your attention to the fact that the results shown in this table are the actual yields obtained without any corrections; that they are from only one of our soil-experiment fields, of which we have more than twenty in various parts of the State, from near the Wisconsin line almost to the Ohio River; and that the results which I have given in detail, while they furnish some of our most decisive data, are yet in harmony with the general average of all results on similar soils, and not only with other plat experiments and field trials, but also in harmony with pot-culture experiments and with the chemical composition of the soil.

H. J. WATERS, of Missouri. Have you been able to see the gain the first year from the application of finely ground rock?

C. G. HOPKINS. A good many of our experiments with the ground rock began this year. Last year, as an average of 16 tests where we applied ground rock without any organic matter, we made a gain of 4.6 bushels per acre; where we applied it with stable manure we made a gain of 8.6 bushels above that made by the rock phosphate without the organic matter.

H. J. WATERS. I would like to ask Doctor Armsby if he has computed the results of the experiments that have been made with unacidulated rock at the Pennsylvania station.

H. P. ARMSBY, of Pennsylvania. Those experiments ran three or four rotations and were then discontinued. They showed no material superiority of the soluble over the insoluble phosphates.

A MEMBER. Why is it that the nitrogen gave increasingly larger results when used year after year with the phosphorus?

C. G. HOPKINS. Where we were using phosphorus without nitrogen the nitrogen would run down in the soil, because no legume crops had been used. It is very necessary to make annual applications of nitrogen in order to keep up the nitrogen in those soils. It is an element the supply of which will be exhausted quickly if we do not take some measures to preserve and maintain it. Phosphorus, however, is the controlling element, as you will see from the averages. We can not draw any conclusions from a single yield on a single plat, but the averages from four different tests show that the first year nitrogen produced an increase, each year the increase growing larger, until in the fifth year it was 6 bushels of wheat.

Potassium produced the first year an average of 6 bushels of corn to the acre, and if we needed any further evidence that would add a little more strength to the statement that we must not draw any final conclusion from one year's work, it is quite evident to me that the action of this potassium salt was a corrosive action. We know that common table salt will increase the yield of many lands for several years, but the result is not permanent. And here the average of the tests for the four years shows that more potassium was not needed in this case.

I would say that potassium frequently produces an injurious effect; that its use as often results in a decrease as in an increase.

R. J. REDDING, of Georgia. I discovered fifteen or sixteen years ago in my first experiment on our soils that potash in any form containing chlorin was oftener injurious than beneficial, and we try now to be very particular never to apply an excess of such salt.

C. G. HOPKINS. I might say that where our soils are very low in available potassium we apply potassium as we did in this soil and get marked increases. On our peaty and swamp lands we apply not less than 100 pounds or perhaps 200 pounds per acre of potassium sulphate or muriate. We have increased the yield from 4 or 5 bushels per acre up to 70 bushels. Those lands are exceedingly low in that element, although they are the richest soils in nitrogen and phosphorus.

Some of our southern Illinois soils which are low in available potassium, also give us a marked increase in corn and cowpeas, and also in clover, with potassium, and heavy applications of it.

In all our experiments calcium carbonate is used. We assure ourselves that we have it in the soil. We always add lime, if necessary, to correct the acidity of the soil.

B. C. BUFFUM, of Wyoming. I think the Wyoming station threw some light on the reason for the reduction of the crop by the addition of the potassium salt by its work with alkali soil. I was very much interested in Dr. Wheeler's late bulletin on the use of sodium salts, but I think he would have found a great deal of difference if he had used the sulphate instead of the chlorid in those experiments. We have found that the reduction of the germinating power of the seeds and the growth of plants seem to be proportional to the osmotic pressure of the solution when these salts are added, and the chlorid always produced more effect than the sulphate. I have always obtained negative results in fertilizer tests on Wyoming soils with potassium chlorid, and some reduction with sulphate. There seems to be plenty of the chlorid associated with the alkali in those soils, and if we add the potassium in this form it reduces the yield.

H. P. ARMSBY. Doctor Hopkins's paper was on the very important question of the maintenance of the fertility of the soil on a large scale. I do not rise to discuss the question or to criticise what has been said, but to suggest that this seems to me to be the very kernel of his paper, and personally I would be glad to hear discussed the question of the maintenance, on a large scale, of soil fertility.

R. J. REDDING. Several days ago I was asked by a farmer what was the value of the phosphoric acid, potash, and nitrogen in an acre of average Georgia soil. I happened to have at hand an analysis of such a soil and I made a calculation of the amounts of the different ingredients in available form at the market prices. The result was over $1,900 an acre. I think it might help us to impress on the farmers the importance of developing the amount of plant food in the soil to know that $1,800 or $2,000 worth of it is within easy reach of the farmers and what are the methods and what are the tools and implements which may be used to develop it.

W. M. HAYS, Assistant Secretary of the U. S. Department of Agriculture. I am very much interested in the discussion. I want to especially call attention to one or two relations of this paper to the work that Doctor Hopkins is doing in Illinois. One is the division of the State into these soil and agricultural areas and the following out of the detailed study of chemical facts and relations with schemes of organizing farms on a system of rotation. I think his scheme of analyzing the general situation of the whole State and working up schemes of farm management that will enable the farmer to see best how to keep up the fertility of his land and increase the yield of his crops so that he will have the maximum crops, and yet retain the fertility of the land, should be studied by all.

C. E. THORNE, of Ohio. The experience of the Ohio station would seem to me to bear strictly upon this paper. The station purchased three adjoining farms lying on the same general geological formation. The soil, so far as superficial examination would indicate, originally was practically, if not identically, the same. On one of these farms, for the last seven years, one-half of the soil having been cleared from the original forest for this work, we have maintained an average yield of wheat, without any fertilizer whatever, of 35 bushels to the acre. We have been able to increase that yield by the addition of acid phosphate alone to 42 bushels per acre as the average of seven years. We have not been able to increase it any further by any addition of nitrogen, or potassium, or both. On another of these farms, which had been subjected to exhaustive husbandry before it came into the possession of the station, the average unfertilized yield of wheat has been between 8 and 9 bushels to the acre. Where acid phosphate has been used on this exhausted soil it has raised the yield for the seven-year period to about 18 bushels to the acre, and we have been able to raise it by the use of acid phosphate, potassium, chlorid, and sodium nitrate to 29 bushels to the acre. I mention this to bring out the point that experiments made on unexhausted soils may give a very different result from those conducted on old and exhausted lands, and we must take that fact into consideration in our advice to the farmers of the State. It is paying us, on this exhausted land, to purchase nitrate of soda for the purpose of growing wheat and corn and oats, but we are trying to teach the lesson there in Ohio that nitrogen may be obtained infinitely cheaper by the growing of leguminous crops and saving the barnyard manure. Therefore we join Professor Hopkins heartily in saying that no farmer can afford to purchase nitrogen in the form in which we find it in these so-called "complete fertilizers," notwithstanding the wonderful effect such fertilizers are producing on this exhausted land.

H. P. ARMSBY. I suppose Pennsylvania has the oldest experience in plat experiments, and our results there fully confirm the experience of Professor Thorne and Professor Hopkins, in so far as the economic feature goes. Our soil is formed of disintegrated limestone. We find a marked increase of production from the use of nitrogen, applying about 120 pounds to the acre. But this increase is in no instance, I believe, a profitable increase. With potash on our soil we get more marked results than Doctor Hopkins reports upon his soil, but with the nitrogen the results fully confirm his, so far as the profit is concerned, on a soil of probably rather more than average fertility.

WILLIAM P. BROOKS, of Massachusetts. The experiments in the Hatch experiment stations have been on soil which had been subjected to cultivation possibly longer than most of the soils which have been referred to, and I rise to make two or three points clear, if possible, in connection with the results upon one field where we have followed a system of fertilization, similar at least in outline, to, though differing in detail from that to which Doctor Hopkins has referred. These experiments have occupied a field that had been in grass a good many years without manure. This was broken up in the spring of 1889 and planted to corn. The average yield of four nothing plants was at the rate of about 30 bushels to the acre. It was replowed in the fall and replanted in corn the next year, and gave a yield at the rate of about 40 bushels to the acre, without manure or fertilizer. Those same four nothing plats have been left without manure or fertilizer ever since, and we have followed a general rotation for the last seventeen years, including in the seventeen years eight corn crops, while the land has been seeded to mixed grasses and clover twice. Each time it remained in grass two years and each year it was mown twice. Now at the present time the plats in that field which have not received manure or fertilizer in all this period yield what, by courtesy, I call about four bushels of shelled corn to the acre—at that rate. I say "by courtesy" because I figure bushels not by shelling, but by weight, and call 80 pounds at husking time a bushel. But the crop on these plats was practically all "nubbins"—there was really no corn there. This land, then, has produced, and will now produce, after sixteen or seventeen years without manure or fertilizer, three or four bushels of corn to the acre. We have had one plat in that field which every year throughout the seventeen years has had an application at the rate of 160 pounds of muriate of potash per acre, and the last time that plat was in corn the yield was between 49 and 50 bushels of shelled corn to the acre. Another plat to which we have applied nitrate of soda annually at the rate of 160 pounds per acre gave us a yield of corn scarcely more than the nothing plats.

Potash alone, or in any of the combinations—and we used it in the same combinations as Doctor Hopkins—increased the crop in a marked degree every time.

One of the first points I want to make is to support Doctor Hopkins in his position that in the case of general farm crops the farmer need not purchase nitrogen. In proof of that I point to the result on the plat which every year during the seventeen years has had muriate of potash and dissolved boneblack—that being the phosphate we have used. The last time that plat was in corn it gave a yield at the rate of 56 bushels of shelled corn to the acre, while the other plat which had received the same quantities of potash and phosphorus, and in addition nitrate of soda, every year at the rate of 160 pounds to the acre, gave a yield of only a small fraction of a bushel more. The crops were practically identical, after sixteen years. It was one year ago when the land was in corn last. Now, in all that time we have not cultivated a legume by itself. We have not green-manured the land. Whenever it was in grass, it was cut twice annually, and the product all carried away; and still the nitrogen content of the soil has been so kept up that we get this yield of corn, which is very good from our point of view, where for seventeen years we have been using only phosphoric acid and potash.

I would say that the character of the herbage on the plats was as different as it could be. Clover would come up on all the plats, but it would die in a short time where nitrogen and where nitrogen and phosphorus were applied, and would live only where there was potash; and where there had been used constantly phosphorus and potassium only, the product was almost wholly clover. On some soils, of which we have very many, without doubt, in New England, the different elements seem to be so evenly balanced that we can not consider the question of what is required apart from the crop. For it makes all the difference in the world what the crop is. On this very field that I have been talking about potash controls the crop absolutely when it is corn or clover, as you would expect; but when we seed to mixed grasses and clovers, we get an excellent crop of hay on the plat where we use nitrate of soda only, for nitrogen is the controlling element for the hay crop with us, and may very profitably be used for that crop.

If into the rotation a crop like cabbages or turnips is introduced, phosphoric acid is invariably the controlling element. In Massachusetts, therefore, we are not justified in talking about what our soils require apart from the crop; with us it is what the crop requires.

We have raised rye in rotation, and there the nitrate of soda was the controlling element, although the response of the rye was not quite as decisive in favor of any one element as was the response of some of the other crops.

H. J. Wheeler, of Rhode Island. We have many soils in our State where, if we would advise our farmers to use fine phosphate rock on certain classes of crops, they would find themselves in bankruptcy before long, simply because those plants, as Professor Brooks pointed out, can not use phosphorus in that particular material readily if the land is in a very exhausted condition. Doctor Hopkins's work, as I understand, applies to the cereals exclusively. But, being a body here representing the whole country, we ought to remember that his discussion is confined to the cereals. I can emphasize what Professor Brooks says. We find that while we have applied no potash to the soil for years, we can nevertheless get a very good crop of redtop, a surprisingly good crop, but you can not get a single plat of clover to grow unless lime and potash are added, We have tried the clover four years on certain plats, and we could not get good results, and we could not get good results with the Cruciferæ, but when we put on Japanese millet and certain other things, they seemed to thrive. If there is anything in the plant family that is a scavenger I thing it is redtop. It will thrive and give magnificent crops where the turnip and the beet and the Cruciferæ are all absolute failures. Therefore, I say when we are considering these questions we must remember that Doctor Hopkins's conclusions apply to two or three crops, and can not be applied generally throughout the United States, nor to all kinds of crops.

William P. Brooks. As Doctor Wheeler has referred to the question of different phosphates, you may be interested in the results which have been obtained at Amherst in comparing phosphates. We have one field where for twelve years we have been comparing phosphates, on the basis of phosphoric acid, applied of course to all plats equally. With liberal and equal amounts of nitrogen and potash on all. The phosphates under comparison have been raw and steamed bone, raw bone, acid phosphates, dissolved bone, and we have South Carolina and Florida phosphates, and phosphatic slag, and the results vary very widely with the crop. With a crop of cabbages there is a marked difference, and the best results are with acid phosphates and dissolved boneblack, and dissolved bone meal and the slag; and one of the poorest returns is given by South Carolina rock, while the Florida phosphate is no better than nothing. But if we put the field in corn, as we have done, the crops are substantially equal on all the plats in the field. I am now putting that field for the first time into grass and clover, but in general it is the Cruciferæ only that have shown marked difference in their capacity to make use of these phosphates.

W. R. Dodson, of Louisiana. There is one phase, I think, which has not been entered into fully enough in the discussions. It seems to me Doctor Hopkins was looking further into the future than we are ordinarily given to looking. I refer to that phase of his paper that was looking to the duty we owe to posterity; that we should not look at this in the spirit of merely putting something in the soil and getting back from it all that we can, but that we should consider that our children and their children are going to have possession of this soil. We know that by doing certain things we stimulate conditions so that we get more from the soil than if we had not added that stimulant; that we are gradually robbing the soil of elements to an extent we scarcely realize. We want to bring our people to understand that while there is a great supply of nitrogen that we can get by means of the leguminous plants, the supply of bone, and the supply of rock phosphate, so far as we can see, is some day going to be insufficient for the phosphate demand of the crop.

This, then, is the great question, looking into the future: How are we to manipulate these crops in rotation, and how are we to handle our system of fertilization, so that we can hand this soil down to posterity in an unimpaired condition? While we can see our way to furnishing whatever potash or whatever nitrogen we need, so far as we can now see there is danger of the phosphoric acid becoming depleted, and there is no source of supply from which what will be necessary can be furnished.

J. L. Sheldon, of West Virginia. I believe we are getting down to the principles in agriculture which have been so emphasized by Marshall Ward, the English authority from which he deduces the proposition that the plant is the foundation of all work in agriculture; that the soil, the moisture, etc., are merely the environments. We are trying to grow all kinds of plants on the same kind of soils. In other words, we are trying to raise horses on swill, and hogs on straw. Is it not time that we began to study the plant and its food, and how that plant can best get that food, so that we can make a profitable crop? It seems to me that the question is not so much with regard to the soil or the chemistry of the soil, as it is with regard to the plants themselves, and how we can best stimulate these to bring us profitable crops.

C. G. Hopkins. There are two different points that have been raised which I would like to refer to for a moment. One of them I might speak of as price, and the other as percentage.

Whether the use of any given material upon our soils for growing crops is economical or profitable depends more largely, than many of us stop to think of, upon the price we allow for that material when it is produced. Even in raising a crop of hay, near some eastern market where that hay crop brings $15 to $20 a ton to the farmer, you can pay anything, almost, for the materials you use to grow that crop; but when you get out into the agricultural regions of the West, where the farmer gets a net return of only $3 a ton for his hay, of course he can not pay much for such materials.

Take the work Director Thorne has spoken of in Ohio; when we figure on the prices that he mentions, using nitrogen and potassium, it paid very well, figuring wheat at a dollar a bushel, corn at 50 cents a bushel, and oats at 33⅓ cents a bushel. But when I have taken the most recent figures from the Ohio experiment stations and applied them to Illinois conditions and considered them in relation to the last ten years, neither nitrogen nor potassium has paid for itself upon the basis of the Illinois yield. It makes all the difference in the world what prices we allow for our produce.

The other point which I wish to mention was raised by Director Redding, of Georgia, regarding the large quantities of plant food in our soils. Even in our soils in Illinois we have 600 pounds of phosphorus per acre. We are coming to look upon the phosphorus in the soil as being available by some sort of percentage; that is, we do not look upon that 600 pounds as being so much that we can slice off at will. We are limited partly by the amount of decaying organic matter, and also by the seasonal conditions, and we are also limited by the root development. Some plants have more extensive root systems which may touch more of the soil particles than others, and if an estimate of the plant food which we can get may be made by calculating the percentage of the surface of the soil particles touched by the surfaces of the roots there would be some percentage relation there. If we can get 1 per cent of the phosphorus from the soil with the ordinary cereal crop, such as clover; if we can get out 1 per cent of the phosphorus in the soil in a normal season, when we have present 600 pounds, we get, of course, 6 pounds of the phosphorus out in the season. If we can get out 2 per cent of the phosphorus in the soil, we would get 12 pounds out. If we had 2,000 pounds of phosphorus in the soil, on the percentage basis of 1 per cent we would get 20 pounds, and with 2 per cent of the phosphorus made available to the root system we would get out 40 pounds. It means a great deal more to us to put it directly upon some percentage basis. What that percentage basis is, actually, we do not know. We must make it as large as we can, profitably.

W. J. Spillman, of the U. S. Department of Agriculture. Unfortunately for myself I did not hear all of Doctor Hopkins's paper, but as the general subject is the maintenance of permanent soil fertility, I want to call attention to the importance, from my point of view, of one class of investigations which have not been carried on as extensively as I should like to see them carried on in our experiment stations. Of course I realize very fully that each of us gets a different point of view from the field of agriculture, and I may have misconceived the importance of a certain line of work. I think we will all agree, however, that where it is possible to do so the use of barnyard manure is perhaps the most legitimate means of maintaining permanent fertility, but it is not always possible to do that. That is particularly true in the South, where I have done most of my work, having been called there more often. In the South they have not been able to develop cattle farming. They have been farming longer than you have in Ohio or Illinois, and they have worn their lands out seriously. They have turned to apparently the only source of fertility they have, namely, commercial fertilizers, and have made very large use of them. Some of the States spend as much as 10 per cent of their crop values for commercial fertilizers. The continued use of these materials without barnyard manure has left very large areas of the South with an extremely bad condition of the soil; all over the Piedmont region it has become necessary to terrace the land. A great deal of the farming there is done on stair steps; they are compelled to terrace, otherwise the soil will wash away. It has been demonstrated by the experience of some farmers that, even on hilly land, with an abundant supply of humus in the soil, this washing may be prevented. Barnyard manure is not available and can not be made available to the average farmer in that section at the present time. The other means of developing humus in the soil is green-manure crops. Now, I should like to see these crops studied more than has been done. It is true that some of the stations have carried on interesting experiments and obtained interesting results, but I find myself unable to answer very many of the questions that come up every day from farmers. One of the things that need to be done is to give more attention to fitting green-manure crops into cropping systems. I find in most of the Southern States rye, vetch, crimson clover, and so on fit beautifully, on paper, into almost any cropping system you can arrange. You can sow any of those crops in cotton just after the first picking, and turn them under the next year for corn, at least theoretically. I am anxious to know more about such crops, their effect on the soil, and on the crops which follow them. It seems there are certain crops which you do not dare to plant after plowing under a heavy green crop. Wheat, for instance, does not do well after plowing under a big crop of cowpeas. It seems to do better if you harvest the cowpeas and plow under only the stubble. The same is true of fall-sown oats. On the other hand, it appears that corn is not very particular about acid in the soil, and potatoes especially appear to do well after turning under a heavy green growth. We want more information about how to grow these crops. Frequently, when we try to grow them they fail. The farmer wants to know how to make them succeed.

I merely take this opportunity of calling the attention of investigators to this problem, in the hope that some of them will take my view of its importance and give more attention to it than has been given in the past.

At 5.30 o'clock p. m. the section adjourned until 2 o'clock p. m. next day, November 15, 1905.

AFTERNOON SESSION, WEDNESDAY, NOVEMBER 15, 1905.

The section was called to order at 2 o'clock p. m., by the chairman, H. J. Patterson, of Maryland.

UNIFICATION OF TERMS USED IN CHEMICAL ANALYSIS.

C. G. HOPKINS, of Illinois. It may be remembered that at the last annual meeting a committee was appointed on the unification of terms to be used in reporting results of chemical analysis, and I would state that a similar committee was also appointed by the Association of Official Agricultural Chemists. Both of these committees have under consideration the general subject, and the committee for the chemists' association has prepared and had printed by the Bureau of Chemistry a preliminary report upon the unification of terms. The desire of both committees has been to get together and make a combined, or unanimous report, so that there would be complete harmony in this; but there is a feeling in both committees that we need more time, and particularly do we need more assistance from those interested in chemical work and agricultural education before making any final recommendations.

The report submitted[a] contained unanimous recommendations with regard to terms to be used in reporting analyses of feeding stuffs, foods, sugars, and insecticides, but the committee was unable to agree as to terms to be used in soil and fertilizer analysis, the disagreement being with regard to the use proposed by Doctor Hopkins of the "element" system of nomenclature.

The report was accepted.

H. Snyder, of Minnesota, presented the following report of the committee on methods of testing cereals:

REPORT OF COMMITTEE ON METHODS FOR THE TESTING OF CEREALS.

The committee on methods for the testing of cereals has undertaken, during the past year, a brief review of the methods employed in the testing of wheat for commercial purposes. Because of the extent of the subject, work with the other cereals was not undertaken this year.

The methods employed in the grading of wheat by the different States and commercial bodies are based largely upon the physical properties, as weight per bushel, uniformity, plumpness, size, hardness, color, and soundness. There appears to be but little literature available giving the actual flour yields of different types and grades of wheat. The work that has been found upon this point indicates that the yield of flour from both soft and hard wheat varieties is directly proportional to the weight per bushel of the grain.

In the case of soft wheat, Mr. David Anderson, a practical miller of Noblesville, Ind., has prepared a chart from actual experience, giving the yield of soft wheat flour from wheats of different weights per bushel. This chart is based upon the thoroughly cleaned wheat, an especial aspirator being used for this purpose.[b]

Milling chart—Soft wheat.

Weight of wheat after aspirating, clean test.	Flour to bushel.	Food to bushel.
Pounds per bushel.	*Per cent.*	*Per cent.*
64.0	80.00	20.00
63.5	79.25	20.75
63.0	78.49	21.51
62.5	77.74	22.26
62.0	76.98	23.02
61.5	76.23	23.77
61.0	75.47	24.53
60.5	74.72	25.28
60.0	73.96	26.04
59.5	73.21	26.79
59.0	72.45	27.55
58.5	71.70	28.30
58.0	70.94	29.06
57.5	70.19	29.81
57.0	69.43	30.57
56.5	68.68	31.32
56.0	67.92	32.08
55.5	67.17	32.83
55.0	66.41	33.59
54.5	65.66	34.34
54.0	64.90	35.10
53.5	64.15	35.85

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[a] See U. S. Dept. of Agr., Bureau of Chemistry Circular, "Preliminary Report on the Unification of Terms for Reporting Chemical Analysis."

[b] N. W. Miller, October 23, 1904.

From the chart it will be observed that when wheat weighing 60 pounds per bushel is milled into flour, 73.96 per cent of all grade of flour is secured and 26.79 per cent of feed or offals. While wheat testing 64 pounds per bushel yields 80 per cent of flour and 20 per cent of offals, wheat testing 55 pounds per bushel yields 66.41 per cent of flour and 33.59 per cent of feed. Mr. Anderson has proposed this chart as a basis for the purchasing of soft wheats, and has constructed tables giving the commercial value of flour and feed when wheat is at different prices per bushel.

In the case of hard wheat, Mr. Foster, chief inspector of the Northwestern Consolidated Milling Company, has proposed the following table based upon the average weight of 100 kernels:[a]

Milling test—hard wheat.

Wheat kernels.	Weight.	Flour.
	Troy grains.	*Per cent.*
100	46	74.1
100	44	73.6
100	42	73.2
100	40	72.6
100	38	71.8
100	36	71.0
100	34	70.3
100	32	69.6
100	30	68.7
100	28	67.6
100	26	66.8
100	24	66.8

From Mr. Foster's table it will be observed that the yield of flour from hard wheat is directly proportional to the average weight of 100 kernels. It is believed that these two tables will give an approximate idea of the flour yields of wheat. Experiments at the Minnesota Experiment Station have also shown that the yield of flour is directly proportional to the weight per bushel of the wheat.[b]

While the weight per bushel of wheat may serve as an index to the flour yield, it does not give the value of the flour for bread-making purposes. Experiments have shown that the lighter weight and lower grades of wheat produce flour of equal, and in many cases superior, bread-making value to heavier weight wheat.[c] It is not possible to accurately estimate the bread-making value of a wheat from its weight per bushel or its commercial grade. The color and hardness of the kernels are the physical properties which are the most valuable in determining the bread-making qualities of wheat, but from the data available it is not possible to formulate even tentative standards based on hardness.

It has been found, however,[d] that in the same sample of wheat grown from a uniform lot of seed kernels of different degrees of hardness are present, and that the darker colored and more horny kernels contain the largest amount of protein. This difference in color and density may serve as a means of selecting glutinous and starchy wheats for seed purposes, provided the comparisons are confined to similar varieties which have been grown under like conditions.

It has also been found that it is not possible to select high-grade wheats on the basis of nitrogen content alone, as shrunken and light-weight grains generally have the maximum nitrogen content; but a high nitrogen content associated with a well-filled kernel is highly desirable, provided the nitrogen is in the part of the grain used for flour-making purposes and not in the germ or offal parts.[e]

No definite relation appears to exist between the total nitrogen content and the bread-making value of wheat. Two wheats may contain the same amount of nitrogen and have entirely different values for bread-making purposes, and a wheat of average nitrogen content may produce better bread than one containing a larger amount. Wheats containing a low percentage of nitrogen are invariably of poor bread-making value, as are also occasionally those of average, even high, nitrogen content. A. D. Hall, of the Rothamsted Experiment Station,[a] recommends the determination of nitrogen as a means of selecting "strong wheats," provided the wheats are grown under similar conditions. "But this correlation is only approximate and true for an average of samples, often failing entirely when applied to individual cases."

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[a] Encyclopedia Americana, Wheat.

[b] Minnesota Sta. Bul. 90.

[c] Minnesota Sta. Bul. 85; Ontario Agr. College Bul. 14.

[d] Minnesota Sta. Bul. 85; Kentucky Sta. Bul. 113.

[e] Ontario Agr. College Bul. 14; Nebraska Sta. Bul. 89.

In determining the relation of gliadin to the bread-making value of flour, experiments have shown that, like the total nitrogen,[b] it is valuable in a general way, but taken alone and as the only means for determining commercial value, it fails, as do all other single tests, in absolutely determining the bread-making value of a flour.

Mr. A. E. Humphries, at the recent International Conference of the Milling Industry, held at Paris, in speaking of the relation of gliadin results to the bread-making value of flour, said: "In a general way they agree relatively with the gluten figures; perhaps of the two sets of figures they more nearly approximated to baking results."

It is quite evident that at the present time there are no laboratory methods based on the analysis of the wheat alone that can be used for determining the bread-making or commercial value of wheat. It appears that this can best be arrived at by actual bread-making tests of the flour made from the wheat.

A number of different kinds of miniature experimental roller mills have been devised for wheat-testing purposes. These mills, when properly manipulated, are valuable for preparing the flour samples for determining the comparative bread-making value of a sample of wheat, but they fail to give the actual flour yield. This, however, can be approximately determined from the weight per bushel of the grain.

The committee begs leave to reserve for future reports recommendations of methods for preparing the flour and making the technical tests.

The report was accepted.

A paper by A. M. Peter, of Lexington, Ky., was read by the secretary of the section, as follows:

SOME RESULTS OF AN OLD METHOD FOR DETERMINING AVAILABLE PLANT FOOD IN SOILS.

Happily the day has passed when a chemist may devise a method of analysis from purely theoretical considerations, often imperfectly understood, and then feel justified in putting forward his method as the true and infallible standard, without having tested its accuracy by the determination of known quantities under working conditions. He who pursues this course in these days may expect just criticism at the hands of his contemporaries. Nevertheless, soil chemistry, and even analytical chemistry generally, is still burdened and clogged with the débris of many such methods.

The conditions affecting the availability of plant foods in soils are so complex that theory alone would be a dangerous guide. The amount of available plant food in a given soil is not in field practice an absolute and fixed quantity, like the percentage of gold in a given sample of ore, for instance, the exact amount of which may be determined with great accuracy. The question of availability is rather a question of relative solubilities, and it will now be generally admitted that any method for the determination of available plant food in soils to be of practical value must be comparative, and gauged by experience in the field. And at the present time a vast amount and great variety of material suitable for such comparative studies is within the reach of our agricultural chemists in the experimental fields of the agricultural colleges and experiment stations. The Association of Official Agricultural Chemists has done well to engage in this work, but when, at its annual convention in 1894, it made the beginning by instructing its reporter on soils and ash to make a study of methods for determining the available plant food in soils after the ideas of Dyer, Dehérain, and others, it was not even then necessary to go abroad for a precedent to justify this measure, for an extensive investigation upon the proposed lines had been undertaken forty years before in this country and carried out on an extensive scale under State auspices—an investigation which clearly proved not only that the diminution of the gross amounts of plant food caused by cropping could be demonstrated by chemical analysis, but that the amount of plant food capable of being extracted by a weak solvent and presumably available to plants was diminished also as the soil became less productive. This investigation had for its fundamental proposition the comparison of rich soils against the same after they had been impoverished by cultivation, with the expressed object to ascertain what constituents had been diminished in quantity and solubility and to furnish a guide for the agriculturist in replenishing the same. Such was the work planned in 1854 by Dr. Robert Peter, chemist, and David Dale Owen, chief geologist, of the Kentucky Geological and Agricultural Survey; and because the results are hidden in a series of State reports long out of print is the writer's excuse for presenting a summary of them here.

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[a] Jour. Bd. Agr. [London], 11 (1905), p. 327.
[b] Jour. Amer. Chem. Soc., 27 (1905), p. 1068.

In those days there were no experimental fields under careful and continuous observation, from which the chemist might draw samples for comparative analysis; but the large areas of virgin land in Kentucky, more especially in the Bluegrass region, offered standards of great fertility, while in the cultivated fields examples were to be found of the depletion of available plant food resulting from continuous cropping under an improvident husbandry. To get material for comparative analysis it was planned to collect samples of soils in sets of three: First, the virgin soil; second, soil of the same type from an adjacent old field ten to fifty years in cultivation; third, the subsoil of the old field. These samples were submitted to analysis by digestion in hydrochloric acid of 1.1 specific gravity to determine the acid-soluble mineral plant food, and also by digestion in water saturated with carbon dioxid under a pressure of two atmospheres. While the first process or "general analysis" gave very interesting and instructive results, showing in a large majority of instances a material diminution of mineral plant food by cultivation, it is with the latter that we are now concerned. And the writer has tabulated about a hundred analyses, taken at random, but using only such as exhibited the complete set of virgin soil, old field soil, and subsoil of old field.

The digestion in carbonated water was performed by putting 30 grams of air-dried soil into a strong 8-ounce bottle, filling quickly with the charged water, thus using approximately eight parts of solvent to one of soil, and corking securely. The bottle was then put in a warm place, where the temperature never exceeded 100° F., and allowed to remain about a month, shaking well each day. The liquid was then filtered out, evaporated to dryness, and the residue weighed, burned, and weighed again to determine "organic and volatile matter." The mineral part was then dissolved in hydrochloric acid, and the solution analyzed in the same way as for the "general analysis." It was soon found that the amount of phosphorus contained in the extract was exceedingly small, even when the soil was very rich in this substance. So the determination was omitted. The extracts often contained very noticeable quantities of manganese, especially in the most fertile soils; but this determination was rarely made. Therefore neither of these determinations is tabulated. The determinations of soda and silica have also been omitted from the tabulation, because they showed no regularity and seemed to have no possible significance. These irregularities are easily explained by the fact that the soda determination is a difference, subject to relatively large errors, and by the difficulty in obtaining the soil solution perfectly clear by filtration. The table gives a comparison of the total extract, organic and volatile matter in the same, precipitate by ammonia, calcium carbonate, magnesia, sulphur trioxid, and potassium oxid in thirty-three sets of three samples each, from twenty-three Kentucky counties, representing five great geological divisions, as compiled from analyses by Dr. Robert Peter, State geologist, in 1854–1859. The full-faced type is used when the quantity is less in the virgin soil than in the cultivated soil or greater in the subsoil than in the top soil.

Extract by digestion in carbonated water—Analyses calculated as parts per million of the air-dried soil.

County, Kentucky.	Total extract, dried at 100° C.			Organic and volatile matter.			Precipitate by ammonia (Al_2O_3, Fe_2O_3, etc.).			Calcium carbonate ($Ca\ CO_3$).			Magnesia (MgO).			Sulphur trioxid (SO_3).			Potassium oxid (K_2O).			Geological position.
	Virgin soil.	Old field.	Subsoil.	Virgin soil.	Old field.	Subsoil.	Virgin soil.	Old field.	Subsoil.	Virgin soil.	Old field.	Subsoil.	Virgin soil.	Old field.	Subsoil.	Virgin soil.	Old field.	Subsoil.	Virgin soil.	Old field.	Subsoil.	
Boone	4,600	3,100	1,936	930	380	277	563	240	63	2,330	1,947	1,120	190	136	139	74	45	22	223	82	66	Lower Silurian or Ordovician.
Bourbon	8,078	3,149	2,263	1,133	517	308	672	422	205	3,630	1,830	1,413	194	105	75	39	25	22	164	78	62	Do.
Do	6,760	2,834	2,671	1,975	583	442	1,588	496	222	2,763	1,305	1,530	58	88	136	65	45	45	154	102	64	Do.
Bracken	9,861	3,333	1,454	2,250	585	470	1,063	147	130	5,420	1,573	447	649	591	133	61	73	40	104	71	48	Do.
Campbell	2,874	1,386	864	1,000	433	283	713	187	107	781	403	97	128	32	69	50	65	49	79	48	41	Do.
Carroll	4,890	4,342	2,019	1,317	1,170	490	980	963	297	1,730	1,563	830	183	156	66	85	145	50	228	96	56	Do.
Clark	5,633	3,600	2,400	1,717	533	500	280	114	80	2,887	2,231	1,447	149	92	67	41	32	30	94	87	61	Do.
Do	2,633	1,917	2,194	705	467	833	167	181	114	1,347	781	814	89	110	67	33	45	41	35	54	58	Do.
Garrard	7,634	4,586	3,186	1,230	883	600	930	913	547	4,413	2,117	1,580	323	140	90	41	22	25	386	152	49	Do.
Do	4,932	3,343	1,409	1,000	917	483	853	407	320	2,488	1,620	273	111	117	43	56	41	34	94	79	35	Do.
Do	1,400	2,383	1,974	533	483	273	81	80	88	263	1,330	1,185	73	Lost	93	22	Lost	22	102	Lost	54	Do.
Franklin	2,380	1,525	1,436	580	240	282	143	163	63	997	607	614	130	56	53	60	78	136	130	79	47	Do.
Do	4,083	3,037	897	692	783	392	688	463	55	2,113	1,280	163	208	158	50	28	39	28	96	94	46	Do.
Do	2,076	2,896	2,054	583	633	367	145	230	64	787	1,507	1,130	123	144	113	41	50	33	66	77	38	Do,
Grant	3,170	2,590	1,428	730	413	237	180	222	130	1,199	1,082	430	109	146	333	39	43	34	137	122	71	Do.
Harrison	4,847	4,077	3,093	1,217	917	550	563	530	230	2,580	2,080	1,831	72	100	83	62	67	62	185	168	131	Do.
Henry	4,617	2,439	3,382	1,383	250	1,440	930	487	301	1,677	1,280	1,313	128	96	33	45	56	45	185	58	32	Do.
Kenton	2,460	1,705	1,630	770	270	370	337	160	223	880	780	410	66	113	44	37	22	17	125	85	96	Do.
Mercer	5,200	5,310	4,090	1,230	1,150	817	813	963	580	2,247	2,530	2,047	190	83	94	46	73	39	166	64	35	Do.
Do	11,095	3,754	6,157	1,550	540	666	980	280	230	7,813	2,613	4,870	400	66	76	61	32	32	77	32	38	Do.
Scott	6,114	6,578	3,599	1,540	1,470	550	494	253	230	3,663	4,497	2,383	101	76	139	45	45	28	71	58	35	Do.
Oldham	2,100	1,547	1,237	677	340	420	113	63	63	557	700	253	133	100	90	253	62	53	91	69	85	Upper Silurian.
Jefferson	2,783	3,066	1,500	600	467	270	114	81	47	1,580	1,730	780	144	105	111	28	81	33	103	77	31	Do.
Lewis	2,650	2,936	1,695	820	733	290	100	413	173	930	1,247	730	245	194	203	22	48	28	137	33	22	Do.
Clark	3,777	5,790	1,893	1,327	1,190	750	853	1,453	330	987	2,296	1,113	172	233	259	37	56	45	93	26	15	Devonian.
Marion	3,409	4,478	1,360	1,460	1,800	110	473	473	120	1,063	1,830	767	133	111	61	36	36	22	87	53	59	Do.
Madison	9,550	3,600	3,743	2,693	550	560	581	147	167	4,287	1,903	1,974	838	405	420	50	28	39	208	33	35	Do.
Larue	1,586	1,970	1,134	715	683	450	163	463	43	317	453	173	108	61	81	39	33	31	74	83	96	Subcarboniferous.
Hardin	2,742	1,992	2,093	827	800	750	687	647	230	830	163	713	63	72	61	17	33	33	106	83	83	Do.
Do.	2,823	1,917	1,078	741	417	233	231	121	47	1,213	730	447	236	120	127	Lost	28	28	89	61	32	Do.
Daviess	4,433	3,720	1,587	1,340	800	340	218	168	68	1,660	1,798	498	266	233	106	188	90	113	142	83	73	Coal Measures.
Jackson	2,450	2,483	1,500	917	700	467	813	463	246	130	497	163	90	159	80	28	34	45	45	93	148	Do.
Do	3,833	4,750	2,283	1,067	1,883	450	1,163	1,030	480	580	1,140	230	141	161	133	30	22	22	66	135	173	Do.
Average of 33 analyses	4,469	3,216	2,159	1,129	730	476	566	407	197	2,004	1,498	1,023	189	142	113	55	50	40	126	79	61	
Highest	11,095	6,578	6,157	2,693	1,883	1,440	1,588	1,453	580	7,813	4,497	4,870	838	591	420	253	145	136	386	168	173	
Lowest	1,400	1,386	864	533	250	110	81	63	43	130	163	97	58	32	33	17	22	17	35	26	15	
Less in virgin than in cultivated soil.	11 or 33 per cent.			4 or 12 per cent.			8 or 24 per cent.			13 or 39 per cent.			11 or 34 per cent.			16 or 52 per cent.			5 or 16 per cent.			
Greater in subsoil than in top soil.	5 or 15 per cent.			8 or 24 per cent.			3 or 9 per cent.			7 or 21 per cent.			13 or 47 per cent.			5 or 16 per cent.			9 or 28 per cent.			

The diminution in amount of soluble materials in the old field soil is very striking, especially in the important plant foods, potassium and calcium. The very apparent differences of solubility between the top soil and subsoil emphasize the well-established fact that the plant food of the subsoil is of relatively low availability.

IMPORTANCE OF THE METHOD OF SAMPLING.

If we bear in mind that the samples of top soil for this investigation were not taken to uniform depth, but were taken to the point where a marked difference was noticeable between top and subsoil, not exceeding 10 inches, meaning an irregular depth of from 4 to 10 inches, and also that the samples were not averages in the true sense of the term, but were obtained by digging in one spot, the regularity of the above results is even more remarkable. Unquestionably, for a comparison of this kind, the samples of top soil should be taken to a uniform depth, not exceeding that ordinarily turned by the plow, and it is also important to obtain an average by mixing portions taken from many places. No assayer would consider his work well done if he took for his sample a shovelful of ore from one place in a carload; neither should the agricultural chemist be content with his shovelful of earth from one spot in seven or eight hundred tons composing the first 6 inches on an acre of land. The writer believes the old directions for collecting soil samples are unfortunate and affected by theoretical considerations that have no determinable relation to the practice of the farmer. If one sample be taken to the depth of 10 inches because the soil shows no difference of color above that depth, and another is taken to 7 inches because of a change of appearance there, while the farmer plows all to 7 inches, we have put ourselves out of relation with his work and have obscured existing relations in the one case by mixing into our sample an uncertain amount of material admittedly poorer in available plant food than that which comes into use, while in the other case we get only that which is actually used. From the chemical standpoint, as well as from the standpoint of the farmer, it is the character of the first few inches of top soil that determines whether the crop will thrive or fail. If the first roots of the young plant do not find within easy reach enough available food to support a healthy, vigorous growth they will never be able to penetrate to the subsoil for the necessary supply of moisture and additional food, and the crop will be stunted or a failure. The writer does not desire to discourage the analysis of subsoils in connection with top soils, but advocates sampling to uniform depths, the first, representing the top soil, being well within the depth of ordinary plowing. In the work of the Kentucky station 6 inches has been selected. The samples are taken preferably by means of a tube made of 1¼-inch steel bicycle tubing provided with a tempered steel cutting edge, so constructed that the core of soil cut out is a little less in diameter than the interior of the tube, and reenforced at the top by a heavy steel ring. With such a tube of proper length samples can be taken to a considerable depth without disturbing the surrounding soil and with very little effort. A core from the first 6 inches weighs about 100 grams, so that ten or fifteen cores will give enough soil for the usual processes of analysis, and the sample so taken will represent a much better average than if taken from only one spot. Difficulties may be encountered with these tubes in a soil filled with small stones, and it may be necessary in such cases to have recourse to the spade or other large tool, but the tube will be found much the best in most situations.

The method with carbonated water, like the method of Dyer with citric acid, is an attempt to imitate natural solvents, but in using water more strongly charged with carbon dioxid than is the natural soil water the principle is recognized that the solvents used in the laboratory must be stronger than the natural ones if we would produce in a short time effects commensurate with those resulting from the long-continued action of natural solvents in the field aided by the continuous removal of certain constituents from the solution by the plant roots. This selective action of the roots of plants is a process very difficult to imitate in the laboratory, although it must be a very important factor in determining the result in the field. But even admitting that carbonated water may be satisfactory, under proper conditions, as a solvent for calcium carbonate and that a determination of the potash dissolved simultaneously may give valuable information, the very nature of the solvent renders it difficult to apply in known and constant strength. And its inefficiency in dissolving phosphates renders it useless as a means of determining the availability of the phosphorous compounds. There appears to be no practical or theoretical reason why a dilute solution of one of the more active acids, such as hydrochloric or nitric, may not serve a better purpose than a supposed natural solvent. Indeed, taking into consideration our present knowledge of the process of nitrification in the soil, we are justified in classing nitric acid as one of the natural solvents. The writer gives the preference to nitric acid, not from theoretical considerations, but because it dissolves less iron from the soil than either hydrochloric, oxalic, or citric acids. In the laboratory of the Kentucky station N/5 nitric acid has been adopted as the solvent for measuring the availability of phosphorous and potassium compounds in soils. The digestions are made at room temperature for five hours, with occasional shaking, using the calculated weight of air-dry soil equivalent to 220 grams moisture-free and 2,200 cubic centimeters of solvent and taking for the potassium and phosphorous determinations, usually, aliquots equivalent to 60 and 100 grams of moisture-free soil, respectively. If a nitrogen determination be made and also a digestion in HCl 1.115 specific gravity, and determinations of potassium and phosphorus in that solution, a very satisfactory statement is possible of the amounts of the immediately available and reserve plant food present. After several years' use we think the method gives results that are in reasonable agreement with conclusions from field experience. The following is presented as an illustration of the practical application of comparative soil analysis.

A field of about 15 acres of apparently good bluegrass soil in Clark County, Ky., was plowed from clover in the spring of 1894 and planted in tobacco. On a rectangular area of about 4 acres in one corner of this field the clover had been almost a total failure. The tobacco began to grow well, but after two or three weeks the tobacco on this same area stopped growing, and at cutting time very few of the plants were worth saving, whereas on adjacent parts of the field—indeed, on nearly all the rest of it—there was an excellent crop. The longest boundary line between the good and bad tobacco was straight and well defined, running at right angles to the rows, and as the tobacco had been set by machine, working continuously, the possibility of differences in time of planting, kind of plants, or manner of setting was here eliminated. Neither was there any appreciable difference in the appearance of the soil on opposite sides. The writer collected for comparison two sets of average samples, each containing ten cores by the sampling tube, taken in parallel lines about 20 feet apart on each side of the apparent line of division between the good and bad tobacco. A set of samples was taken also from a bluegrass pasture on another part of the same farm, which had not been in cultivation for a great many years. These samples were given a very thorough analysis, including determination of acidity, nitrites, nitrates, and humus. Only the most important determinations are here given.

Analyses, calculated on the moisture-free samples, parts in 1,000,000.

	Good tobacco.			Bad tobacco.			Pasture.	
	First 6 in.	Second 6 in.	Second 12 in.	First 6 in.	Second 6 in.	Second 12 in.	First 6 in.	Second 6 in.
K_2O by fifth-normal HNO_3	97	7	9	16	17	11	323	208
P_2O_5 by fifth-normal HNO_3	5,552	6,952	7,652	7,768	8,120	7,984	8,520	7,820
CaO	7,000	8.600	8,500	8,700	7,900	8,000	9,400	9,300
K_2O by HCL 1.115 sp. gr	5,490	--------	--------	6,460	--------	--------	6,380	--------
P_2O_5 by HCL 1.115 sp. gr	13,350	--------	--------	17,550	--------	--------	16,950	--------
Total N	2,280	1,580	1,020	2.380	1,060	1,040	3,080	2,080
N of nitrates and nitrites	3.8	1.5	0.5	30.1	6.0	3.0	5.8	1.7

The low solubility of the potassium compounds in the soil where the crop failed points to the cause of the failure, and warns the farmer against planting tobacco again on any part of this field unless artificial fertilizers be used to supply the want. The same cause is suggested for the failure of the clover. The relatively large proportion of nitrogen in the form of nitrates and nitrites in the bad part of the tobacco field shows that this part was equivalent to a fallow, the tobacco not having made growth enough to consume the nitrates. The effect of this was very apparent on the wheat and bluegrass sown after the tobacco, much the best growth being on the part where the tobacco had failed. If these analyses had been made before the tobacco was planted instead of afterwards, it is probable the crop on 4 acres of this field would have been saved by the use of ten or twelve dollars' worth of potash salts.

Incidentally it is to be noted in connection with these analyses that one of them shows the highest percentage of phosphorus that the writer has ever observed or seen reported in any soil—amounting to 1¾ per cent of phosphorus pentoxid. The very large amount of available phosphorus compounds in these samples renders the differences noted in available phosphorus of no significance.

C. G. Hopkins, of Illinois. I would like to say a word about the amount of phosphorus reported in this paper. I have made a computation from the figures given, and I find from 12,000 to 15,000 pounds of the element phosphorus to the acre, which is about ten times the amount we have in our Illinois soil. It is, of course, quite generally known that many of the soils in the region of Tennessee and Kentucky, and even in the Piedmont section in other States, run very high in phosphorus.

M. A. Scovell, of Kentucky. Our bluegrass lands are very full of lime, and streaks and nodules of phosphate of lime occur in many places in the soil, but even the virgin soils are lacking in potash, and we must supply it by artificial means.

W. J. Spillman, of the Bureau of Plant Industry. It seems to me that in this case it is clear that the limiting factor is potash, and the result given by the methods of analysis agree with the results of the crop. Now, immediately the question arises that where potash is the limiting factor and the result agrees with field tests, we should like to see it tried on a soil where phosphoric acid is the limiting factor.

We must not confuse the available amount with the amount the plant uses. It does not use, and could not very well use, all the phosphoric acid available in this soil.

Soil Investigation.

A paper upon this subject was read by C. E. Thorne, of Ohio, as follows:

The dream of the earlier chemists, that chemical analysis would prove to be the magic key which would unlock all the mysteries of plant growth and soil fertility, has proven to be only a dream; for, while chemistry has made and is still making contributions of priceless value to our knowledge of the soil on the one hand and of plant nutrition on the other, we have come to realize that our study of these problems must be directed along several lines of inquiry, no one of which may be neglected.

It is a well-known fact that soils derived from limestones are, as a rule, much more productive than those originating in noncalcareous rocks; while these rocks again produce soils differing widely in character The geological origin of a soil is therefore a matter of prime importance in determining its value; but this origin is not always revealed by analysis, either chemical or mechanical, hence no classification of soils can be accepted as satisfactory which does not take this factor into consideration.

It is very true that our information respecting the relationship between geological origin and practical adaptation is, as yet, very imperfect, and the extension of the boundaries of knowledge on this subject is, in my judgment, one of the most important objects toward which soil study should be directed. There is in existing agricultural and scientific literature a very considerable accumulation of data upon this question, which if collated by an expert soil geologist, might be made very useful as the point of departure for further studies along this line.

Within very recent years we have learned that biological factors play a very important rôle in the soil, but as yet we stand only at the threshold of knowledge on this subject. The discoveries made in this direction have thrown a new light upon the function of lime in the soil, suggesting that in some cases this function may be chiefly to furnish a base by which the nitric acid, resulting from the growth of the soil organisms, may be neutralized.

EXPERIMENTS WITH LIME AND FERTILIZERS ON AN ACID SOIL.

At the Ohio station, the soil of which is chiefly derived from sandstones and shales, we have had some very interesting experiences in the culture of clover. For a number of years it has been increasingly difficult to secure a satisfactory crop of the common red clover. We get a good stand in the spring and when the wheat crop is removed we find a sufficient number of clover plants, but over considerable areas their growth is small, and remains so throughout the season. There will be occasional patches of fairly good clover, especially where barnyard manure or certain nitrogenous chemical fertilizers have been used, but even in these cases the growth is far from perfect.

Since 1893 an experiment has been in progress at this station in which corn, oats, and wheat are grown in rotation, followed by two years in clover and timothy, the test being duplicated on five tracts of land, so that each crop is represented every season. Each tract is divided into thirty plats. Every third plat is left continuously unfertilized, while fertilizers of different composition are applied to the cereal crops on the plats between. In 1900 we began dressing these tracts with lime, applying caustic lime as a cross dressing to one-half of each plat. The lime has been applied as a surface dressing to the corn crop, and as we plow the corn stubble for oats and the oat stubble again for wheat, the lime is first turned under and then brought to the surface again before the wheat is sown.

We have now harvested three crops of clover hay in this test, and in the accompanying diagrams I have endeavored to show the general outcome. Diagram I represents the seven-year average annual total weight of produce for the cereal crops as found by taking one-third of the total weight of the three crops, and Diagram II shows the three-year average annual weight of clover hay on both the limed and unlimed halves of the plats. The first five years of the test during which the land was being brought under experiment are omitted because of greater uniformity of the later results.

These diagrams have been constructed by taking the average yield of all the unfertilized plats as the basis and adding to this yield the increase found by comparing the yield of each fertilized plat with those of the two unfertilized plats between which it lies.

The diagrams show that acid phosphate, used alone or in combination with potassium chlorid only, has produced a marked increase in the cereal crops, and a similar increase in clover after liming, but in the absence of lime there has been practically no increase of clover from these fertilizers. It is noteworthy that the small increase of unlimed clover after potassium chlorid disappears when acid phosphate is added to the potassium, as shown by comparing plats 2 and 8.

Taking the second section of each diagram, we see that incomplete fertilizers containing sodium nitrate have produced a uniform increase in both the cereals and clover, both with and without lime, the point of interest being the much larger yield of unlimed clover on these plats than where the nitrate has been omitted.

The third section of each diagram shows the yields from the complete fertilizers containing sodium nitrate, which is added at the rate of 480 pounds per acre for every rotation except on plat 12, where the quantity is increased to 720 pounds. Comparing these plats with No. 6, which receives 480 pounds of sodium nitrate with acid phosphate but no potassium, we see that the addition of potassium has evidently increased the yield of the cereals, and still more evidently that of the unlimed clover. Comparing with plat 8, which has phosphorus and potassium, but no nitrate, we see that whereas the unlimed clover on that plat has made no increase, the limed clover very nearly equals the yield obtained from the complete fertilizer. In other words, the combination of lime, phosphorus, and potassium seems to have brought the clover crop to perfection without the addition of any nitrogen carrier, whereas the cereal crops show very plainly the need of nitrogen. Other points of special interest brought out by this section are (1) that the further increase of sodium nitrate on plat 12 has apparently produced no further increase of the unlimed clover, though a small additional increase is shown on the cereals and the limed clover; (2) that the bone-meal plat, No. 26, while materially below the average in cereal yield, shows a full yield of clover, and (3) that the plat receiving dissolved boneblack, No. 27, while giving a full yield of cereals and of limed clover, falls below in the yield of unlimed clover. While the diagram shows a slightly greater weight of hay on the unlimed end of plat 11 than on that of plat 26, the fact is that in two years out of the three the yield was considerably larger on plat 26, indicating that the apparently smaller yield on this plat in the average is due to a variation in soil conditions.

The last section of each diagram shows for the cereals an almost uniform yield for the different carriers of nitrogen, and a fairly uniform yield of the limed

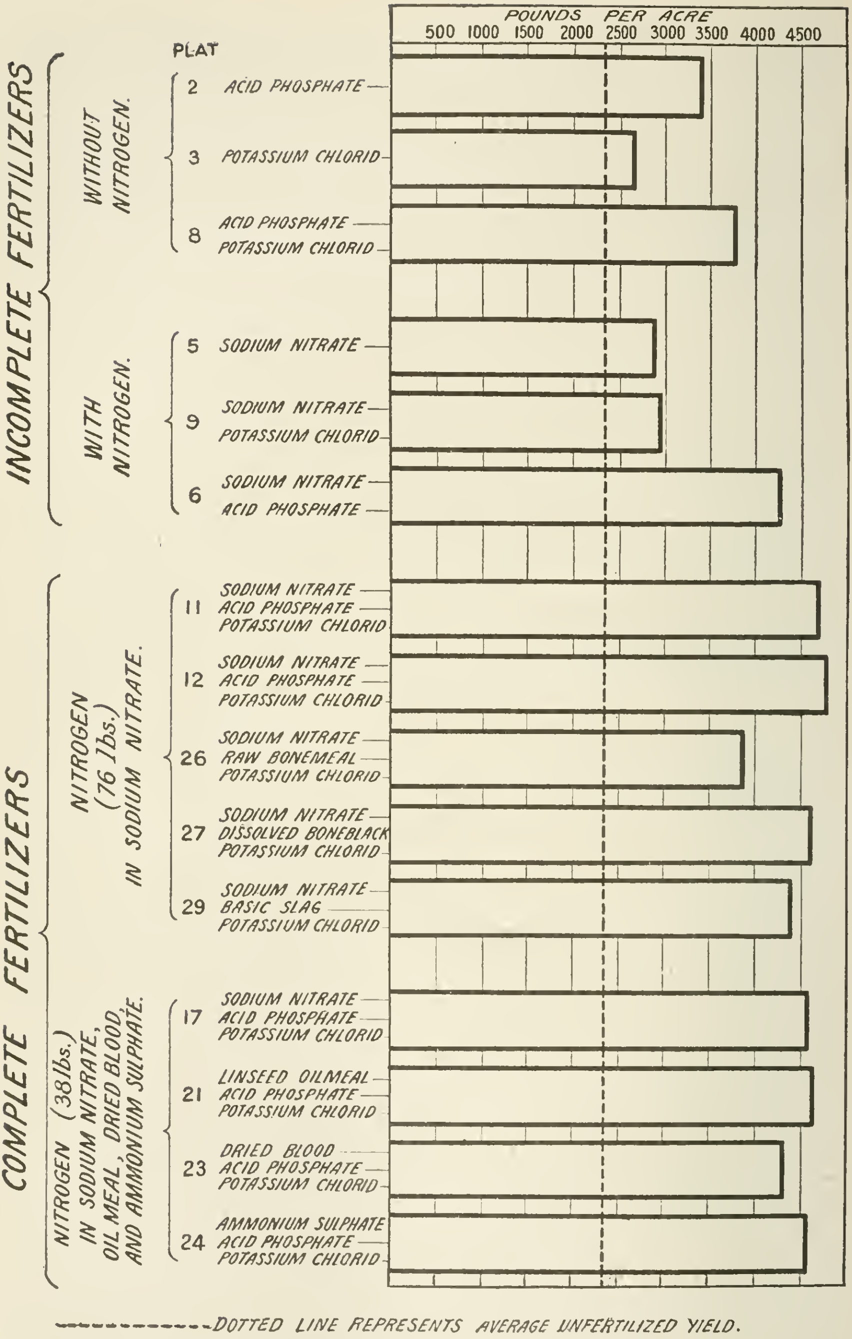

DIAGRAM I.—Seven-year average total produce of corn, oats, and wheat.

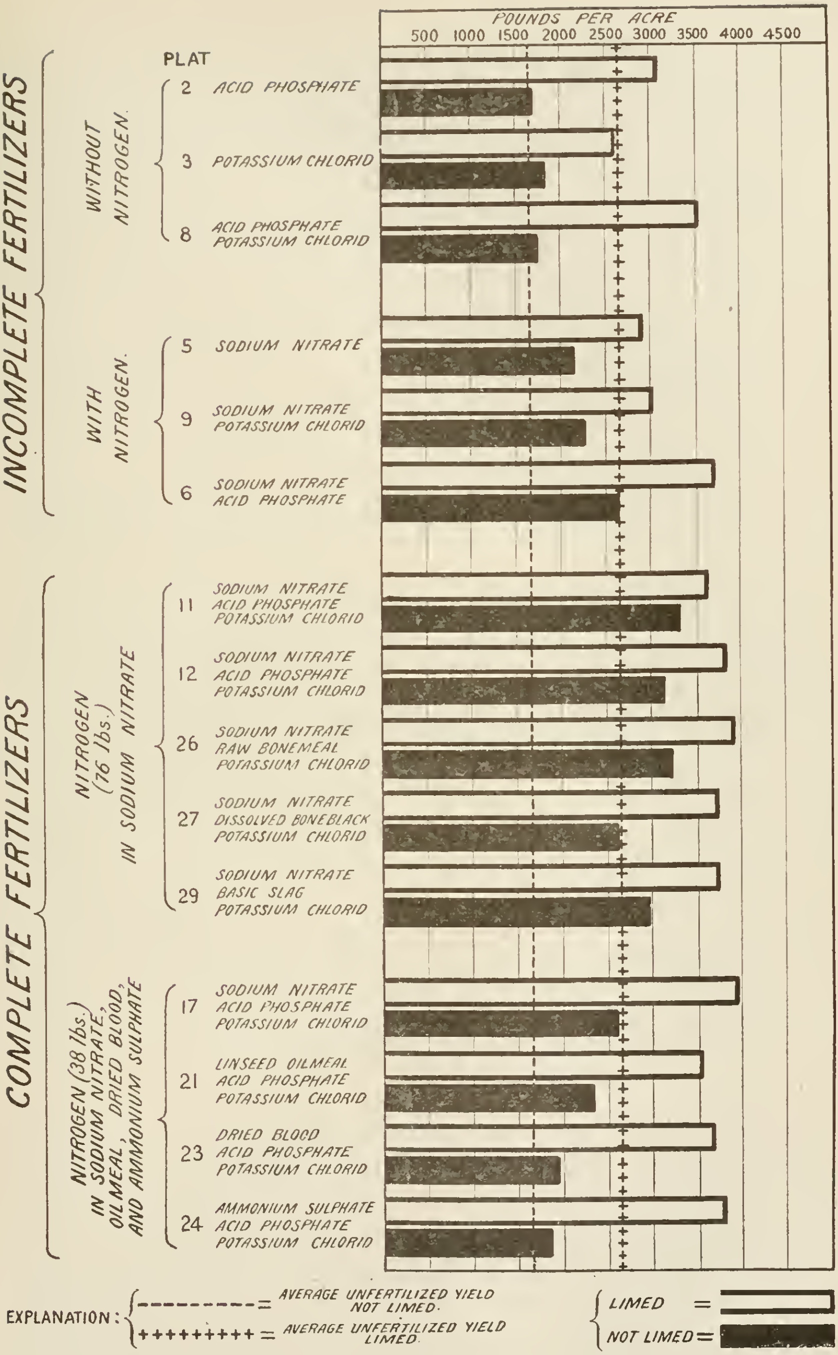

Diagram II.—Three-year average yield of clover hay.

clover; but the unlimed clover shows in every case a lower yield from the other carriers than from sodium nitrate.

Attention is especially called to the fact that the yield of the unlimed clover, following the complete fertilizer containing ammonium sulphate as the carrier of nitrogen (plat 24), is practically identical with that of plat 8, fertilized with potassium chlorid alone; whereas the limed half of this plat produces a yield equaling the average yield from fertilizers in which the nitrogen is carried in sodium nitrate.

Taking the experiment as a whole, it is evident that phosphorus has been the controlling element in producing increase in the cereal crops, and that, after phosphorus, nitrogen ranks next in importance. With clover, however, lime is evidently the substance first in demand. After lime is supplied, then phosphorus and potassium are required, and in the order named. Given plenty of lime, it would seem that nitrogen might be almost entirely dispensed with as far as the clover is concerned, for the results of the test indicate that the increase of clover, following sodium nitrate, is due rather to the sodium than to the nitrogen, the sodium apparently serving to some extent as a base with which the excess of soil acids may combine. This work is still in the tentative stage, but its results show a much greater lime requirement in the soils which have received no sodium nitrate than in those which have been dressed with that substance.

The effect of this liming on the cereal crops has been to increase the yield of corn and oats by about 10 bushels per acre, and of wheat by a smaller quantity. The liming has also apparently slightly increased the effectiveness of the fertilizers, but this increase has been small as compared with that observed on the clover crops.

The outcome of these experiments raises a host of questions:

In the first place, what is the meaning of the increasing acidity of this hard-run soil? Is it due to an organic or a mineral acid? If to the former, why does its increase seem to be in inverse ratio to the amount of organic matter left in the soil by the growth of crops, and why does the use of sulphuric acid in fertilizers increase the difficulty? If the acidity is of inorganic origin, what is the cause of its increase on soils which have not received acidulated fertilizers? Is it the acid itself which is injurious to clover, or is the acidity merely a symptom of some other toxic condition? And why does the common red clover suffer so much more from this toxic condition than the cereal crops, and alfalfa still more than red clover? In what way does lime act to correct this unfavorable condition? Does it simply serve as a fertilizer, satisfying the lime hunger of the plant; and is its superior effect on clover, as compared with th cereals, due to the much greater relative lime requirement of clover than of the cereals? Or is the effect chiefly due to the setting up of conditions more favorable to nitrification and to the functions of the symbiotic bacteria? What is the meaning of the great effect of sodium nitrate on clover on unlimed land, and of its meager effect on clover on limed land? Is the sodium furnishing an alkaline base to neutralize the acidity of the soil? If this were all that is required, would not a large application of sodium nitrate dispense with the necessity for lime, which it seems not to have done, in the case of these experiments, although it has considerably reduced the effect of lime?

THE STUDY OF SOIL ACIDITY AT WOBURN.

The Woburn experiments of the Royal Agricultural Society of England are conducted upon "a light sandy loam, deficient in lime," a description quite applicable to the Wooster soil of the Ohio station. In these experiments wheat and barley have been grown in continuous culture since 1876, with different fertilizing compounds. Plat No. 2 has received a mixture of the sulphate and chlorid of ammonia without any other fertilizing material, and for twenty years this plat produced good crops of barley; but at the close of this period a condition set in much resembling that which has become manifest in the clover in the Ohio experiments, the growth first being spotted and uneven, and finally failing almost completely. This soil was found to show a decided acid reaction to the litmus test. In 1897 lime was applied to one-half of this plat, with the result that the former luxuriant growth of barley was restored, whereas on the unlimed half the growth became continually more feeble. The wheat crop did not begin to fail on the similarly treated plat until several years later, but by 1903 it also was showing signs of distress. In pot-culture tests both barley and wheat were found to be much more susceptible to this trouble than oats.

In the Woburn experiments sodium nitrate produces no such unfavorable effect as that following the use of ammonium salts. In these experiments, however, a mixture of the sulphates of potassium, sodium, and magnesium with superphosphate has apparently produced no injurious results as yet upon the barley crop, the effect of this dressing corresponding to that observed upon the cereal crops on plat 8 in our tests. When to this dressing, however, ammonia salts are added, the yield is reduced to a point below that of the unfertilized land unless lime is added, but with lime the mixed minerals and ammonia salts produce a larger yield than the same mixed minerals with an equivalent quantity of nitrogen carried in sodium nitrate.

Doctor Voelcker has studied, by pot tests, the effect of these fertilizing substances upon the physical condition of the soil, and finds:

"(1) That there is a great difference in the mechanical condition of the soil produced by the different applications, in regard to the caking of the surface and the rapidity with which water passes through it. Thus distilled water (say rain water) goes through most slowly, the moisture being mostly retained; nitrate of soda forms a hard crust on the surface, thereby often retaining the water on the surface; with sulphate and muriate of ammonia a crust is also formed, but the drying of the soil causes large fissures to appear, and through these the liquid flows away more quickly than in the other cases.

"(2) Variable amounts of organic matter are removed, the distilled water removing comparatively little, while ammonia salts give deeply colored solutions when the drainage first runs.

"(3) As regards removal of lime, it has been ascertained that the order in which this, as well as magnesia, is washed out is: (*a*) (the least) water, (*b*) nitrate of soda, (*c*) sulphate of ammonia, and (*d*) (the most) muriate of ammonia. The rate of removal of lime is about twice as rapid with muriate of ammonia as with nitrate of soda. The results with potash, phosphoric acid, etc., are being worked out.

"(4) It has been noticed that the rate of removal of lime varies greatly with the season of the year, being most active in the spring and summer (the time of most active nitrification) and almost ceasing toward the winter, but commencing again the following spring." [a]

He has also attacked the question as to the nature of the acidity of this soil, first by thoroughly washing the soil, and, second, by drying it on a stone floor for several months. Both methods resulted in the removal of the acid character, and, further, the acidity of the liquor from the washed soil disappeared after exposure for a time to the air. Discussing these results Doctor Voelcker says:

"At first sight one would be disposed to think that the acidity might arise from sulphuric acid or hydrochloric acid consequent on the continued use of sulphate and muriate of ammonia on a soil poorly supplied with lime. But this has been shown not to be so, for the washings of the soil * * * are not acid with either of these two acids; however, the fact that the acidity passes off equally on the exposure of the soil to the atmosphere and on exposure of the soluble liquid poured off when the soil is washed shows that it can not be due to mineral acids, but is more probably the result of a feebly soluble organic acid or acid salt." [b]

Doctor Voelcker has carried this inquiry further by growing plants in soil from this plat (1) after it had been exposed to the air as above mentioned, (2) after thoroughly washing it, (3) in soil taken from the headland of the field and treated with liquid used in washing the acid soil, (4) in a check pot of the untreated soil from the acid plat, and (5) in another to which calcium chlorid had been added. The results were that neither wheat nor barley would grow on the untreated soil nor on that treated with calcium chlorid, but both grew well on the washed and exposed soils, and also on the soil treated with the water used in washing. From these results Doctor Voelcker draws the following conclusions, stating, however, that they are only preliminary and require much further investigation before they can be definitely formulated:

"(1) That the acidity of the soil, brought about by the continual use of ammonia salts, or else the condition of soil consequent on its formation, is the cause of the failure of the land to produce barley and wheat.

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[a] Jour. Roy. Agr. Soc. England, 64 (1903), p. 357.
[b] Ibid., p. 358.

"(2) That this acidity can be removed by exposure of the soil either to water and air together (as when it is repeatedly washed with water) or, to some extent, by exposure to air alone (as when it is spread out in the open in the dry condition); after this it will grow quite good crops of barley and wheat.

"(3) That the failure of crop growing does not consist alone in the removal of lime from the soil, inasmuch as if the acid be removed (as above) the soil still has enough lime to support a healthy crop.

"(4) That the oat crop is not injuriously affected by the soil acidity of the extent that wheat and barley are.

"(5) That removal of lime from a soil takes place far more rapidly when ammonia salts are used than when nitrate of soda is applied, and that muriate of ammonia is a more potent agent in removing lime than sulphate of ammonia, the latter, however, being more exhaustive of lime than nitrate of soda.

"(6) That the effects of the acidity thus produced can not be removed by the use of a neutral salt like calcium chlorid, but that this can be done by the employment of lime, after which healthy crops of barley and wheat can be again secured.

"(7) That the acidity would seem to be due not to soluble mineral acids, but, possibly, to weak organic acids or to acid salts."[a]

THEORIES AS TO THE CAUSE OF SOIL ACIDITY.

Samples of the Ohio soil have been examined by the Bureau of Soils, U. S. Department of Agriculture, and Doctor Whitney, Chief of the Bureau, reports as follows:

"The soil grains themselves are very acid to litmus and a faintly alkaline solution of phenolphthalein, but not to methyl orange. The aqueous solution prepared from the soil is only slightly acid as compared with the acidity of the soil grains themselves, showing that the acid of the soil is only very slightly removed from the soil grains by water. This slight acidity is more marked with phenolphthalein than with litmus, but this is wholly due to the greater sensitiveness of the former indicator. Litmus paper contains always a trace of alkali, and is, therefore, not sensitive to such small amounts of acid. When a carefully prepared litmus solution is used as an indicator with a sufficiently large amount of soil extract the acid reaction is readily and definitely noticed. This acidity persists even after boiling for a considerable time, in fact, after concentrating the solution to one-tenth of its original volume, thus showing that the acid reaction is not due to carbonic acid. As, however, the solution, either in its diluted or concentrated form, does not show an acid reaction with methyl orange, it follows that the acid present belongs to a class of weak acids, probably an organic acid, or possibly an acid phosphate.

"On heating the soil to redness for a sufficient length of time to burn out the organic matter and then treating with water containing litmus or phenolphthalein the soil does not show an acid reaction, but evidently an alkiline one, indicating that the acidity in its original condition was due to an organic acid and not to an acid phosphate.

"The following considerations will show that this acid substance in itself is not deleterious to the wheat plant, and that the beneficial effect of lime on this soil is due to some other cause than the neutralization of the acid.

"In the first place, we find that when the soil is made faintly alkaline with sodium carbonate or with sodium hydrate the transpiration and growth of the plant is not increased nearly as much as upon the application of lime. Furthermore, by the addition of 250 parts per million of concentrated sulphuric or hydrochloric acid to these acid soils there is no apparent effect seen in the transpiration or in the green weight of the crop. Even stronger arguments follow.

"The addition of 100 parts per million of nitrate of soda to the Wooster soil increases the transpiration from the plants and the green weight of the plant fully as much, if not more, than 1,000 parts per million of lime; that is to say, the nitrate of soda in the above proportion appears to be quite as efficient as the lime in increasing plant growth. The soil, after treatment with the nitrate of soda, in which the plant growth is fully as satisfactory as when the lime is used, is still acid, even after the plants have grown in the soil in this satisfactory manner for some time. In other words, the nitrate of soda does not correct the acidity of the soil * * * but does increase the plant development without removing or changing the acid condition.

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[a] Jour. Roy. Agr. Soc. England, 64 (1903), p. 361.

"If we take up now the extract of the soil we find that the addition of lime or of nitrate of soda will have the same effect in increasing the transpiration and the growth of plants in this extract as they did when applied to the soil itself. We have obviously, therefore, transferred the cause of the infertility of the soil from the soil itself to the extract. We find that by treating this extract with carbon black the transpiration and the yield of green matter are increased almost, but not quite, as much as from the use of lime or nitrate of soda, but here again, although we know that carbon black has a remarkable power of clarifying solutions and removing certain organic impurities, it does not act on all kinds of organic substances, and, whatever effect it may have had upon this soil extract, it does not sensibly diminish its acidity. Plants grown, therefore, in this carbon-treated extract, showing a satisfactory increase in transpiration and in yield, are growing in as acid a solution as in the untreated soil or soil extract. It is fair to suppose, therefore, that in the case of the wheat plant the infertility of the soil is not directly due to the acid substance, but to some accompanying organic product which is changed or destroyed by lime, nitrate of soda, or by carbon black.

"In our experience here at Washington we find on charring a soil, or on treating it with pyrogallol or with manure, that if examined immediately after the treatment the solution may still show the same acid properties, accompanied nevertheless by increased fertility, or these acid properties may even increase by these treatments to a marked extent even to the present detriment of the soil, as in the case of the charred soil which may become caustic and corrosive, but on allowing the soil so treated to weather for some time the acid properties finally disappear. It may be that in a similar way the soil treated with the nitrate of soda, in which some toxic substance has evidently been changed or removed, will upon standing, and particularly with leaching, lose its acid properties because of the destruction or removal of the agents which produced it, or of the substances from which it was formed."

It will be observed that Doctor Whitney and Doctor Voelcker agree in ascribing the acidity of these soils to some other acid than sulphuric or hydrochloric acids, and this assumption is supported by the fact that Ohio soils, which have received neither of these acids in fertilizers, show a similar reaction to the litmus test. With respect to Doctor Whitney's assumption that the fact that this acidity disappears after heating the soil to redness is proof that it was due to organic acids, Doctor Hopkins, of the Illinois station, calls attention to the fact that the ash of organic matter is almost invariably alkaline, and holds that "it is altogether probable that this alkaline ash resulting from the organic matter of the soil would be sufficient to more than neutralize any inorganic acidity which might exist in the soil."

Doctor Whitney discusses this question in the light of experiments on wheat, but both Doctor Voelcker's test and our own show that wheat is relatively insensible to acidity of soil. In the Ohio experiments wheat is producing a fair and increasing yield on the plats which have received the largest additions of acidulated fertilizers, and on which clover has almost totally refused to grow, the average annual yield of wheat for the last seven years being 18.1 bushels per acre on plat 2, 19.2 bushels on plat 8, and 22.8 bushels on plat 24, against an average unfertilized yield of 8.2 bushels. This means that the addition of phosphorous and lime on plat 2, and these, with potassium on plat 8, have enabled the wheat to secure sufficient nitrogen for the production of a yield more than double that given on the unfertilized land. It is possible, and I think quite probable, that the time is not far off when the soil supply of nitrogen will become exhausted, and the addition of mineral fertilizers alone will be insufficient, except where clover has been brought back to its normal functions by the use of lime, but this is for the future.

This far, therefore, progress toward the solution of the soil-acidity puzzle has been a matter of exclusion and we find ourselves still asking the questions with which we started out.

NITRIFICATION AND SOIL ACIDITY.

The work of the nitrifying bacteria of the soil and the oxidation of organic matter is attended with the production of nitric acid, and of perhaps larger quantities of organic acids. This work is going on at the time when the higher plants are in full growth, and their roots, permeating the soil, are in position to absorb at once the nitric acid thus formed. Under natural conditions the nitrogen supply, aside from the small quantity which may be brought down to the soil by rain, is limited by the action of these organisms, and the quantity of nitrogen consumed by the plant will be measured by the amount of available phosphorus, potassium, calcium, and other mineral elements which the soil may furnish. Given a soil deficient in one or more of these elements, but having a physical condition favorable to husbandry, and subject it to a system of cropping and tillage calculated to stimulate the growth of the soil organisms, and we may expect to find the production of nitric acid exceeding its consumption. If the soil be well supplied with lime or some other salifiable base, the excess of nitric acid may be stored as nitrates, which will be held in the soil until used by the plant or washed out by the rain; but in the absence of such a base, and with a rainfall not sufficient to pass through the soil into the drainage, there may be a sufficient accumulation of nitric acid in the soil, together with the organic acids formed as a secondary result of nitrification, to produce a temporary acid reaction. This accumulation of acid will have a toxic action upon the nitrifying organisms which would finally result in limiting nitrification. Let, now, an alkaline base be supplied. The excess of acid will be neutralized, and nitrification will again commence, but unless we furnish not only the base necessary to neutralize acidity, but also such mineral elements as may be necessary to restore the supply of plant food in the soil to equilibrium for the particular crops grown, there will still be a limit to production below that of the normal capacity of those crops.

Therefore, when we add acid phosphate, potassium chlorid, and sodium nitrate to a lime-hungry soil, we may have furnished all the phosphorus, potassium, and lime which the wheat crop requires, while still leaving the lime supply insufficient to feed the clover; and if we omit the sodium the base may be so far insufficient that the toxic effect of the excess of acid will still be manifested in the clover crop, the wheat having consumed all the lime furnished in the acid phosphate. Certainly, under such conditions, the acids carried in the fertilizers would intensify the toxic effect, unless they were so closely adsorbed by the film water of the soil grains as to be completely inaccessible to the plant roots and to bacterial action. It is easy to conceive that such close association might take place as to produce the results which Doctor Whitney has noted in his litmus-paper tests, but my conception of plant root and bacterial action is that it is more vigorous than mere water solution.

Dr. C. G. Hopkins has suggested that future investigation may reveal whether the large accumulation of acidity, especially in some difficultly pervious subsoils, is in the form of organic acids or acid salts, or in the form of inorganic acid salts, such as might result from the reaction of nitric and organic acids upon neutral silicates forming acid silicates; also, whether this acidity is retained in soils because of its very low solubility, or because of its absorption in the film water surrounding the soil grains.

An interesting point in this matter is that this season, when the wheat was taken off the fourth section of land which has come under the experiment with lime, there was no such difference between the limed and unlimed ends of the plats as we had noticed on the three preceding sections. The spring and early summer had been marked by excessive rainfall, a condition which continued until August. After the rains began to diminish, however, the unlimed clover practically ceased to grow, while that which had been limed continued, so that now the contrast is nearly as striking as it has been at any previous period.

Another effect of the excessive rainfall has been the production of the greatest crop of clover, on the second year's growth, which has been harvested in this region for many years. The liberal water supply has apparently accomplished one or both of two effects. It has removed excessive acidity or it has brought into solution a larger supply of mineral plant food in the soil.

In conclusion:

(1) The Woburn and Ohio experiments have shown that the geological history of a soil is a matter that can not be neglected if we would intelligently prescribe for its treatment.

(2) Both experiments show that chemical problems must occupy a position of first importance in any effective study of the soil.

(3) The Woburn experiments have shown that the physical effect of fertilizers on the soil is a factor to be reckoned with.

(4) Both experiments support the belief that no investigation of the soil can be complete which fails to recognize the vast importance of bacterial action.

Finally, my object in presenting this paper has been to suggest some of the problems pertaining to the maintenance of soil fertility which are urgently demanding solution. The particular hypothesis regarding the cause of clover failure which I have offered is a hypothesis only, set up to be established or overthrown by future investigation, and set up in the hope that somewhere the investigator may be found who can unravel the tangle which this particular problem presents, and that somehow the means for accomplishing this great task may be placed at his disposal.

JACOB G. LIPMAN, of New Jersey. We should differentiate, it seems to me, in the study of soil acidity and its relation to crop production, between the purely physiological influence that soil acidity may have—namely, the influence of the dialysis, or the diffusion of the salts, organic and inorganic, outward and inward, taking the plant roots as the dialyzing membrane—and the bacteriological effect.

Take the case of the success or failure of clover. Why is it that clover does not grow well in acid soils? Is it because there are certain organisms in the soil that interfere with proper germination or that exert a solvent action on the young roots, and thus destroy or undermine the vitality of the young plant; is it because there are certain acid substances produced in the soil which interfere with proper dialysis; or is it because those substances interfere with the bacteriological cooperation that is necessary in order that a clover crop—a successful clover crop—might be produced? Of course we do not know just what the mechanism of nitrogen fixation is in the clover plant. We assume—at least those of us who have given more or less attention to the subject—that the first product in the synthesis of protein bodies is a *soluble* organic nitrogenous substance, and, being soluble, it is liable to diffuse outward through the root or through the tubercle proper, and there is no doubt that this substance, diffused outward, influences materially the character of the bacterial growth outside of the root tubercles. Hiltner, of Germany, has proposed a theory according to which it is not sufficient to have the proper bacteria; that is, *Pseudomonas radicicola* alone is not usually sufficient for the growth of leguminous plants. He claims that within the sphere of root action, in the immediate vicinity of the roots and tubercles, there is a bacterial flora which plays an important part in the normal development of the clover; and he thinks he has proved, with regard to these bacteria, that the first service that they render to the leguminous crops is by consuming the store of nitrates in the soil. He says that, since it is proved that the fixation of nitrogen by leguminous crops is discouraged by the presence of nitrates, it follows that this withdrawing of the nitrates from the leguminous crops encourages the fixation of nitrogen.

Whether that is true or not remains to be demonstrated. But there is another point of view, and that is that the soils which are acid, the flora, the bacterial flora, is entirely different from that in alkaline soils, and we know that in certain changes in the soil the formation of soluble nitrogenous substances may keep pace with the formation of the insoluble nitrogenous substances. We may take, in the laboratory, a culture solution containing soluble nitrogenous substances and convert the latter, by inoculation with certain bacteria, into insoluble modifications without the loss of any nitrogen whatsoever. Similarly, the soil nitrates on the soluble organic compounds may be rendered insoluble as fast as they are formed.

If, in the presence of soil acidity, the flora will prevail which will cause the transformation of the soluble into insoluble nitrogenous compounds, then conditions are thereby created that have a very important bearing on crop production.

And, furthermore, if we assume that there are soluble nitrogenous compounds formed within the root tubercles of leguminous plants that they diffuse outward, and that they are rendered insoluble as they leave the plant, then it follows that the dialysis will be thus accelerated, and the nitrogenous substances will be removed very rapidly and rendered insoluble, affecting thereby the character of the leguminous crop.

Then there is another point. Kühn reports a series of experiments where for twenty years he grew nonleguminous plants on rather light soils, with a generous application of potassium salts and phosphates, and there was no diminution in the crop producing power of that soil.

Hall, recently, reports an instance showing that on one of their experimental fields where no leguminous plants were grown for a number of years there was a considerable increase of nitrogen in the soil—several thousand pounds per acre.

A still more interesting experience of our own, an observation made by Doctor Voorhees and myself, was this: In certain sandy soils, where we applied phosphoric acid and potash but no nitrogen, we have been growing millet, which is a very exhaustive crop, for three successive seasons, and yet observed no diminution in the yield of millet. Taking the sum total of the nitrogen yield in the crops, and of the nitrogen now in the soil, and subtracting that present in the soil at the beginning of the experiment and that subsequently added in the seed and water, we find a very large gain from some source.

We do not know what influence the crop has on the growth of the bacterial flora of the soil. There is no question that different crops affect this flora unequally. We know that from crop to crop the bacterial flora may be changed to an astonishing degree. There are certain classes of nitrogen-fixing bacteria which seem to be found in little nests on particles of limestone in the soil, and we may obtain practically pure cultures of them from those little nodules of limestone. These are but a few scattered facts which may throw some light on the interrelation of soil acidity, liming, crop rotation, and the growing of legumes.

While we have looked at soil fertility from different standpoints, and while I do not pretend to regard the bacteriological standpoint as the only legitimate standpoint, yet I think, as Professor Thorne has also pointed out, that the bacteriological problems surely deserve more attention than they are receiving.

H. J. Wheeler, of Rhode Island. What I say to-day you will please accept as tentative and in the line of suggestion rather than as something formal. An attempt will be made to simply point out some of the peculiar and interesting things that arise occasionally as suggestive in relation to soil investigation. Let me refer first to the two-hundredth normal hydrochloric-acid method. This has been tried on some soils, and it apparently shows a considerable amount of phosphoric acid as probably available to plants. The same method of extraction applied in the same laboratory to some of our own soils yielded no phosphoric acid, yet, strangely enough, upon some of the same plats from which the soil was taken we get very good crops of certain varieties of plants.

Now, while there may perhaps be a likelihood of finding a single method of extraction that will tell us as to the assimilability of the potash in soils, it will seem more surprising if we find any single solvent that will tell us for all soils concerning the condition of the phosphoric acid. To make this more clear, let me state that in our own soil we have about 3½ per cent of humus, and there are very fertile soils in the valley of the Rio Grande that have a comparatively low per cent of humus. In our soil a large proportion of the phosphorus is present in the organic matter. In the soil from some other regions a large proportion of it may be present in apatite, iron phosphate, or aluminum phosphate. Is it not too much to expect that any one solvent can show the requirements of these soils in which the phosphorus is present in so many different combinations? This suggests that what we need is a differentiation of the phosphorus in particular soils, and perhaps we shall find that for a certain class of them a certain solvent may be used advantageously, in another class another solvent, and in a third class we must perhaps apply two or three treatments before we can judge of the requirements. It is my hope that some one may take up and study carefully this question of the differentiation of the phosphoric acid in upland soils. We know that the Germans have done a great amount ot work in that direction, particularly in connection with the moor soils in northern Germany, and I believe there is a great opening for investigation in that particular line in connection with our upland soils in the United States. I am ready to be disputed on this point, for perhaps our points of view are not all alike.

There is another line of investigation that I hope somebody will take up. We hear much about humic acid, ulmic acid, crenic acid, and apocrenic acid, and perhaps other acid substances belonging in the same category. It seems to me somebody ought to take up the study of the organic constituents of soils and give the subject an overhauling. To-day we are obliged in some respects to cite Mulder when discussing these matters. To be sure, something has been done since his time, but there is apparently yet a great field for work, and I hope there are some here who will take it up. It will do no harm if more than one station undertakes it. I am not one of those who think it is unnecessary to duplicate work. We all recall the case where two men working at the same time in different parts of the country came to the conclusion that each had found the specific organism which caused potato "scab," yet later it was found that one was right and the other wrong. Duplication of work is not always by any means a waste of labor. For this reason I hope that no one will hesitate to attack these problems because of fear that some one else may be working on them.

Another question that should be studied is the following, viz: What is the influence of the materials that we apply to the soil upon the character of the life within it? Just to give you an idea of what I have in mind I will say that two or three years ago we had just money enough so that we could hire a man to do a little bacteriological work in the summer upon the soil of two plats at our station where sulphate of ammonia had been applied. One had been limed and the other not. Some plants do not grow as well after liming as before, while most varieties of plants grow splendidly where the lime has been applied. Now, it struck me as a splendid plan to inoculate from both the limed and unlimed soil upon both acid and alkaline media; and as a result we found that when the inoculating material was taken from the unlimed soil many more forms appeared on the acid than on the alkaline media. When inoculating from the limed soil the reverse was true. In other words, it appeared that the question of whether the lime was there or not had probably exerted a great effect on the amount and kind of both the bacteria and fungi. And I wondered what influence the greater amounts of these organisms and the particular kinds might have upon the growth of agricultural plants. I had hoped at that time that we might get the money from some source to determine these organisms and to study their action and their influence upon succeeding crops, both upon the limed and unlimed soil. It seems to me that there are many opportunities of this kind upon every experimental farm to study in regard to the influence of specific manures or soil amendments upon the life of the fungi and bacteria of the soil. We have heard much recently concerning soil bacteria and the importance of their study, and it has occurred to me that if they are as important as is sometimes claimed, there ought to be an advantage, aside from symbiotic action in legumes, in inoculating old soils which have been lying neglected for years and to which nothing has been applied in the shape of stable or other manures. One trial of this kind was made last year at our own station, but without result. One lot of neglected soil was inoculated from a good garden soil, and to the other the same amount of sterilized material from the same lot was added. If there is anything practical in the influence of the bacterial life, I fail to see why, by some such inoculation tests, it may not be shown. To the possible objection that it was a case of inoculating with mixed cultures arises the fact that a pure culture introduced into an ordinary soil might not better the conditions. If benefit is found to follow such work, specialists may well be set at work to ascertain to what specific organisms the differences are due. This would seem to be a very suggestive line of work for neglected soils.

There is another much neglected line of soil investigation. We hear much talk about soils and their influence upon the growth of plants. We have not had the means to study this subject in Rhode Island except incidentally, but we have tested the effect of probably about 200 different varieties of plants to see how they would be affected by certain differences. Reference is made to two plats of land where sulphate of ammonia has been used with and without lime, and to two other plats where nitrate of soda has been similarly used. In the case of a few plants liming was injurious in both instances, but for most plants liming was beneficial or absolutely essential to their growth. In view of such diametrically opposite results I do not think we should talk about the condition of soils without considering in the same connection the crops that are to be grown. The two can not be divorced. There are some plants which have twice the range of adaptability of others, and a study of the special range and adaptability of plants to these different soil conditions must not be left out of consideration in connection with soil investigations.

We had a very interesting experience two or three years ago where we had tried nine different phosphates. We planted several varieties of plants across these plats and obtained certain results. The next year a single variety was grown upon all of these plats, and you could go out there and see by the variations in height the marked influence of the previous crop upon the one which had followed. Whether that was entirely caused by removal of plant food, whether it was due in part to the influence on the physical condition, or to some noxious influence of the previous crop, or to other causes, has not been ascertained. There should be in connection with soils a very careful study of the effect of given plants upon the particular plant which is to follow. In other words, I think there should be a study of rotations with this specific object in view. At present I do not know of a single comprehensive and specific experiment of this kind in progress in this country or in Europe. It would seem as if these factors have not been sufficiently taken into account in our studies of soil treatment and soil requirements.

Another question which interests me very much is the influence of the texture of the soil upon the growth of plants. As we all know, there have been a number of experiments conducted under glass, which show that one can not grow lettuce successfully in a compact, heavy soil, and yet carnation pinks will thrive well in it. There is a great difference in plants as concerns the texture of the soil best suited to them, and I believe we must study our soils more, with this point in view. Take for example one of our old exhausted soils in Rhode Island, which has 3½ per cent of humus. It is so fine, so compact, and of such poor texture that with liberal manuring with chemicals one can not secure at the outset a good crop of Indian corn or of potatoes; and yet it will yield a splendid crop of rye. From these things I am led to believe that there is a great field for investigation in finding out the influence of texture upon the growth of crops. This matter, if understood, will influence the arrangement of crops in rotations. If we have a poor texture of soil we must put on first a crop that will grow under those conditions, and toward the end of the rotation we can grow plants which demand a better texture. I may be mistaken about the importance of these matters, but I believe there is a golden opportunity for some one.

There is another matter which has suggested itself to me. We have all been trying for a long time to find a solvent which will tell us in regard to the assimilability of the phosphoric acid in the soil, and as you well know, certain Germans at an earlier date and Professor Hall recently have worked at analyzing plants to see if some hint can not be gained from their composition as to the requirement of the soil where they have been grown. We have done similar work in the past year in Rhode Island by way of several preliminary tests. I wish to emphasize that we do not wish to say that we have anything absolutely definite or positive, but it is at least suggestive. We find that the ordinary flat turnip, when grown upon certain soils, contains twice as much phosphoric acid as when grown upon others, and there was a close relationship between the phosphoric acid in the turnip and the amount of crop produced. All I can say at the present time is that we have no conclusion to offer, but it is suggestive that possibly the ordinary flat turnip may be grown upon a soil, and by its subsequent analysis we can draw conclusions as to whether the soil is well stocked with assimilable phosphoric acid or not. We hope to ascertain what there is in this matter and do not wish to prohibit others from making similar trials.

Another line of investigation of interest has been suggested by our experiments with sodium and potassium salts. We have found like others before us that certain kinds of plants are very grasping in their propensities in so far as concerns taking up potash. In other words, they will take out of the soil more potash than they seem to require. In fact, I think Jordan and Jenter showed in an instance of crops of the same size that ten times as much potash was removed from the soil in one case as in the other. Now, we find that where soda is present certain plants take up large amounts of it. In other words, they satisfy their demand for alkali with soda and take out very much less potash. Sodium seems, therefore, to conserve the potassium supply in the soil. If we are right in this, it seems to me of the utmost importance that an extensive and thorough study should be made to find out in connection with what varieties of plants sodium can conserve the potassium supply. With the potato plant it is probably not possible to any practical extent, and with the cereals and possibly with millet the same may be true, but when we grow at least certain root crops there is no question but what if we apply sodium salts liberally there will be left in the soil much potassium which would otherwise have been taken out. This is another fruitful field for investigation, and I think it is an important one. We propose to do something with it in Rhode Island, but we are not intending to usurp it, and I mention this so that if any of you are interested you will take it up and pursue the question further.

Another thing has been suggested by Professor Loew. If he is right, some soils contain so much lime and so little magnesia and others so little lime in proportion to the magnesia that the best results are unobtainable. It seems to me very important to test the question and see if there are such ill relationships actually existing in our soils as one might infer from his writings, for if so we ought certainly to take the matter more frequently under consideration. Personally, I think that in some instances the difficulty attributed to such ill relationships of lime and magnesia was really due to other causes. Yet I have no doubt there may be very much in it, and what there is ought to be found out.

Finally, I wish to seize this opportunity to enter a protest against the use of the word "humus" without qualification. One reads in text-books, bulletins, and in the agricultural press that soils need humus. Now, I may be mistaken, but I think I have seen soils that had too much humus and which were nevertheless suffering from a lack of organic matter. That may seem paradoxical, but what I mean is that there may be so much humus which has so far advanced in decomposition that it fills up the interstices of the soil sufficiently to interfere with the proper movement of air and water. I hope some day we shall have a committee appointed to determine what terms shall be used.

What seems to be needed frequently is decaying organic matter rather than the "matière nôir" of Grandeau.

C. C. Moore, of the Bureau of Chemistry. I want to emphasize what Professor Wheeler has said as to the possibility of determining the available plant food in the soil, by growing a crop on it and then seeing what is the composition of that crop. If the phosphoric acid is high in that turnip, it would indicate that the plant food in that soil is greater than in that soil which produces a low turnip. I believe that is the very keynote in the investigation of soils. I believe that if the soil investigators would consider the composition of the crop, as Doctor Wheeler suggests, they would find themselves on the most direct line to truth in this research. I have had experience in the Department of Agriculture in making something like 3,000 crop experiments. I have been able to produce crops wherein the yields were identical—that is, within a gram of each other; yet in one instance there would be as much as six or eight times as much potash in one crop as in the other crop. That was simply because I had fertilized that crop with potash. If I had simply determined the yield, this would have indicated that there was no effect of the potash, and I would have been misled.

Again, I have been able to produce enormous crops of straw, but no grain. Now, if I had said that the potash had been ineffective because no grain was produced, I would have been decidedly misled. I have been able in a large series of investigations which I have made to establish no relation whatever between total plant food in the crop and the total crop, or the crop yield.

I think if Professor Wheeler's suggestion is carried out, and the composition of the plant be used in determining the fertility of the soil, it will lead in a more direct line to the ultimate end.

Officers of the Section.

H. J. Waters, of Missouri, on behalf of the committee on nominations, consisting of H. J. Waters, C. D. Woods, and W. R. Dodson, recommends as chairman of the section, B. C. Buffum, of Wyoming; for secretary, M. A. Scovell, of Kentucky; for programme committee, H. P. Armsby, of Pennsylvania; C. F. Curtiss, of Iowa; M. A. Scovell, of Kentucky; for members of the executive committee, W. H. Jordan, of Geneva, and C. F. Curtiss, of Iowa. (See also p. 51.)

The report was accepted.

At 4 o'clock p. m. the committee adjourned to meet at 2 o'clock p. m., November 16, 1905.

Afternoon Session, Thursday, November 16, 1905.

The section was called to order at 2 p. m. by the chairman, H. J. Patterson, of Maryland.

How Much Demonstration Work and What Kind Should the Experiment Station Undertake.

C. E. Thorne, of Ohio. Mr. Chairman and gentlemen, I come entirely unprepared to take part, and especially to lead, in the discussion of this question. All I can do is to crudely outline some of the thoughts that have been passing through my mind of late, without being crystallized into any definite form; but we are feeling this at our Ohio station. We spent ten years there in learning how to experiment. We have spent twelve years in bringing experimental work into such shape as to give definite results. We are now feeling that the work which is to-day most urgently demanded of the Ohio station is that of demonstration throughout the State of the results which these twelve years' work have brought forth. Just how to do that to the best advantage we are not definitely decided. We have, as part of our resources for investigation, several outlying test farms. These we have regarded in the light of, as I have just expressed it, additional resources of investigation. We look upon them as absolutely indispensable to correct work.

Considering not only the problems relating to the maintenance of soil fertility, but also those relating to varieties and their adaptation, and many other questions of general interest throughout the State, we feel that if our work were confined to the one locality where the main station happens to be established—and most fortunately so, we think—the conclusion drawn from that work alone would sometimes be an altogether misleading basis on which to formulate general advice to the farmers of our State. We therefore look upon the help which we are getting from these outlying test farms as of vital importance, and with that help, with the suggestions we get from it and the limitations which it evidently puts upon the results which we are getting at the main station, we are able to speak with far greater assurance that our advice will be safe than we could without this help. These test farms serve in but a very limited way the purposes of demonstration. We expect to make them serve that purpose to some extent in the future, but it will be to a limited extent only that this will be possible. It is but to a limited extent that our work at the main station can serve this purpose. By this I mean that comparatively few farmers of Ohio can personally inspect the work, either at the main station or at either one of these test farms. We feel that this work must be very greatly extended if it is to serve the purpose of convicting and converting the farmers of Ohio, as a class, to the better methods. We can reach some of them through the printed page. We can reach some of them through the spoken word, and we are endeavoring to enlist the cooperation of the farmers' institutes of the State in this part of our work. But, after all, there are some things which must be seen to be believed, or at least there are some things which can only fully impress themselves upon the minds of many people after they have been seen. We have started at the Ohio station a department of cooperative experiments, a special department organized with the idea of enlisting the cooperation of the thinking farmers in every quarter of the State in some of the simpler phases of the station work. We are endeavoring to prescribe for these farmers a few simple experiments: First, in comparison of varieties; next, in a few cultural methods, perhaps, or in certain methods of treatment of seed or of plants for the control of insects or fungus diseases. The outlook at present is very encouraging. We have on our books to-day at least a thousand names of those who have written to us and who are anxious to take up this work. Many of these are ex-students of the college of agriculture of our State, young farmers who have gone back to the farm and who are earnestly thinking over the problems which pertain to their work. We hope that each one of these will become to a certain extent a demonstrator in his immediate neighborhood. We hope to extend the work until we shall have several such men in every township in the State, and we have somewhere near seventeen hundred townships. We are trying to go slowly in the matter, to select from those who apply for work of this kind those who give some evidence of earnestness and capacity and capability for the work, as we realize that it would be very easy to get a large number of names of persons whose interest would be but transient in this matter and who by neglect or careless methods might bring the work into disrepute instead of advancing it. I think we have been extremely fortunate in securing as the head of this department a young man who is full of enthusiasm in this line of work, a young man who had been chosen by the voluntary organization known as "The Agricultural Student Union of Ohio" as its experimenter.

Between this and the best farm there still lies a line of work which it seems to us it will be wise to endeavor to carry out, and that is a line very similar to that which Doctor Hopkins has inaugurated so successfully in Illinois, in which a farm will not be purchased or leased as we have done in the case of our best farms, but arrangements will simply be made with the owner of a tract of land or of an orchard or of a flock or herd of cattle, sheep, or swine, to carry out, under the direction of the station, either through its department of cooperative experiments or through the agency of some of its other departments, certain specific lines of investigation. Our experience teaches us that if this work is to be successfully done we must first find the man on whom we can rely to thoroughly execute the plans which must be agreed upon between him and the particular department of the station in which the work may fall. We must then as thoroughly as possible divorce that man from any pecuniary interest in the outcome of 'the experiment. We have tried the other plan and have found it almost invariably a failure. So long as the farmer feels that the value of the crop to him is the main point at issue, so long will the experiment be neglected, and therefore if it be a field on which we wish to start some of the lines of soil investigation which we have under way we shall lease that field outright, as Doctor Hopkins, I understand, is doing, and we shall own the crop produced upon the field. We will pay the man who has it in charge, or such agent as he may designate, for the labor performed; but the field for the time being will belong, under lease, to the experiment station. If it be a herd of cattle or sheep or swine we shall make, as nearly as possiblee, a similar arrangement. In fact, we have just concluded an arrangement of that kind, by which a considerable number of sheep are to be fed under our direction. We become responsible for any extra feed that may be furnished and for any loss of thrift that may result from the use of our methods of feeding. Of course this may open room somewhere for disagreement, but we hope to so adjust our agreement with the owner that such openings may be closed in a mutually satisfactory manner. In this way we hope to extend the work of the station into the various quarters of the State. We hope to so extend it that within a few years we may have our cooperators in every township and almost in every school district of Ohio, who will be looking to the station for suggestions along the line of certain experiments more or less simple and who will be carrying out these experiments under our inspection and direction, and whose work will be to their neighbors a practical object lesson in that work.

We realize one thing especially in this work, that if it is to succeed it must be carried out under personal inspection on the part of the station, and therefore the plan of organization contemplates the visiting of every experimenter, so far as possible, by the chief of this department of cooperative experiments or his assistant, or by the chief or his assistant of whatever department of the station the work may be carried out under, these visits to be made as frequently as may be necessary to keep proper check of the work, to give proper encouragement to the experimenter, and to see that the results are not thrown away by mismanagement at any time.

I should say that we have been doing something along this line for a number of years, so that the plan as I have outlined it is not a mere theoretical experiment with us at this date. We have been doing work, for instance, in large commercial orchards in Ohio for a good many years, and it has borne rich fruit in some cases; and while we have not done successful work in the field, we have done the unsuccessful work there which has shown us that this method is the one which must be adopted if success is to be attained, and we have the example of the work Doctor Hopkins has done to show that success is within reach along this other line. We also have the fact of the success that a similar department of cooperative experiments has secured over in Ontario. The interest that has been excited there because of this work has been to us a very great encouragement.

I think these are the main points of the work we are undertaking, and I shall be extremely glad to have any criticism upon it, or any suggestions as to the improvement of this work which those present may be able to offer.

P. A. Yoder, of Utah. I would like to ask Director Thorne how frequently he finds it necessary to visit the outlying stations?

C. E. Thorne. We have no fixed rule. We leave that entirely to the discretion of the superintendent, and it varies with the character of the experiment. With an experiment in variety testing I should say, speaking roughly, that two or three visits during the season might be sufficient, but more frequent visits would be better. I would like to visit them every month during the season, and I aim to do it. If I can not visit them personally, an assistant does and reports to me.

In the case of a feeding experiment, I should say it ought to be visited at least as often as that. In the case of an orchard experiment, we might want to visit it two or three times at short intervals at a certain period, and then it might go a long time, perhaps, without inspection. The whole matter must be adjusted with regard to the peculiarities of the situation, the character of the experiment, and the work that is progressing there.

C. G. Hopkins, of Illinois. Our outside work in agronomy is, to some extent, in the nature of demonstration work. For this purpose we take a long-time lease. We have bought one or two tracts of land where we wanted to carry on work particularly in soil experiments, on broken land, where the land is subject to surface washing, and where we wanted to let some of it wash so that after fifteen or twenty years it would be, possibly, almost completely ruined. In a few instances of that sort we thought it best to purchase the land. But in the main, if we think we can get the results in ten years, we take a ten-year lease and pay a cash rent for the land and have it as absolutely under our control as though we owned it. In that way we can get a field frequently right out of the heart of a man's farm, that we can get the history of, and we know that it practically represents the type of soil that we perhaps could not get if we had to buy the land.

The management of these fields is entirely in the hands of the experiment station. We may make use of the labor that can be furnished by the owner of the land, and if he will furnish as cheaply as anybody else will we give to him the preference. We also accord him preference in the purchase of the crop. After the crop is grown, and we take what we need for seed and other purposes, if there is some to go to market the owner of the land has the privilege of taking it at the market price. We do that because we feel that we ought to encourage the owners of these lands by these experiments, and the feeling exists still that there are crops that ought not to leave the farm. We encourage that feeling by giving the owner the first privilege of taking the crop.

We have superintendents who devote their entire time to the management of the work—one man who will look after the soil of the experiment plats and another who looks after the crops of the experiment fields—and they have as much assistance as they need, and these men not only superintend, but do a great part of the work. In the main we have assistants enough to go from field to field. A man may spend a week on one field looking after the work there and seeing that it is properly done, and in some cases doing it. These men are all men of college grade who are thoroughly familiar with the work, and whom some would say, at first, perhaps, are too expensive men for that work; but there is another purpose and value in their going about from field to field. Frequently when our superintendent is at a field there may be a dozen farmers there to see the grain thrashed. These fields are located in different parts of the State on soils which represent large areas of land as typical soils, and when the crop is to be harvested or thrashed there may be fifteen or twenty farmers there to see it, and it is essential that we should have there a man who is capable of explaining the purpose of the work, and who may perhaps give an address to the farmers of half an hour. So that we think it is essential to have a man who is thoroughly well trained and who does not consider it at all above his dignity to drive the drill or drive the binder or shock the grain. That is part of his work, and as high as any other part, because it is necessary to carefully guard results. It is just as essential that we weigh our wheat accurately as that we weigh the calcium oxid accurately in analyzing the soil. If it takes a good man to make the one weight accurately, it takes as good a man for the other.

The question is asked in regard to the size of these experiment fields. They range all the way from 2 or 3 acres up to 40 acres. I think 40 acres is about the largest field we have.

As regards number, length of service, and expenses of men employed, I would say our men will be out all the time from April 1 to December 1, beginning with the seeding of oats—or even the seeding of clover, in March—and remaining until the last shock of corn has been weighed.

The traveling expenses I can not give in exact figures, but all of our men are required to use mileage books in our passenger associations, by which we get transportation for 2 cents a mile, whereas the regular one-way ticket would cost 3 cents a mile. I would say that the traveling expenses, at 2 cents a mile, for one of our men would probably amount to $150 a season.

Board is a very large item, because most of our men board right at the field, but we generally try to locate the fields close enough to a railway station so that livery hire is not necessary, although occasionally we have not been able to do that. We have a fairly good telephone service in the State, and, of course, we have the telegraph, which is always open. With the telephone reaching to the farm, we can frequently, by telephoning or telegraphing ahead, have a man from the farm to meet us, so that the livery hire is light.

Aside from the cost of superintendence, and aside from the cost of the fertilizing materials we apply, which is not very great, some of our fields, even on poor land, are paying the State in the products sold more than the cost of the labor upon them. That we do now, or hope to do, notwithstanding that we do all this work on plats from one-tenth to one-fifth of an acre in size, and everything that is done is done to exact measure. Of course that is, as you are all aware, a very expensive method of farming; but on a number of our fields we are getting sufficient, or more than sufficient on some of our products, to pay for the labor—though not for the superintendence—required.

L. C. CORBETT, of the Bureau of Plant Industry. I am especially interested in this subject of demonstration work, and I confess I am disappointed in what I have heard, because I consider every remark which has been made as applying simply to experimental work rather than administration work. All these tests, and everything that I have heard spoken of, divest the owner of the land of any pecuniary interest in the results. The demonstration work which the Department is endeavoring to carry on is based upon the idea of placing in the hands of the owner of the farm information which will enable him to increase the output of his farm. In other words, it is educational work; it is not experiment station work at all; it is not experimental work. Our conception is to take the results of experiments which apply to any given region and put them in the hands of the farmers, so that they can improve and increase the yield of their fields. That is the kind of discussion that I hoped was coming out of this meeting, and from the general subject one would expect that rather than the experimental phase. Demonstration work and experiment station work, or experimental work, I consider to be absolutely different. Experimental work in many instances, and, in fact, in nearly all instances, is not remunerative; while demonstration work ought to be exceedingly remunerative, because demonstration work ought to take the results of successful experiments which have been conducted on any given soil area, or under given conditions, and put them in the hands of the farmers, so that they can increase their crop production. That is our idea of what demonstration work is, and that is the sort of work we are trying to take to the farmers in the cotton belt, where the cotton boll weevil has been doing its greatest harm. The work I am especially interested in is to go into the areas of the cotton belt, where the people know absolutely nothing, in many instances of horticultural work, and enable them to conduct gardens or small truck areas at a profit. Of course we try to study the soil and market conditions, and all those things which will bear on the ultimate outcome of the work, but we divest it as far as possible of the experiment feature. Now, I realize that that is extension work, or educational work; but to my mind that is true demonstration work, while the other work is experiment-station work, or work of investigation.

C. D. Smith, of Michigan. In Michigan we have adopted rather the view of the last speaker than that of Director Thorne. To give a concrete instance of the work we are trying to do in our feeble way in the land of the two peninsulas, it was quite impossible for us to get the peach growers to really believe that the results of the experiments of the Department of Agriculture were actually true. We had to go around and give them absolute demonstrations. We took a section of an orchard in the midst of a community that was well educated and well grounded in theory, and by actual demonstration taught them that spraying would prevent curled leaf. They had read your bulletins from Washington, and had an inherent belief in the truth of those bulletins, but did not try it themselves until somebody went down there and tried it for them.

We took an apple orchard in the eastern part of the State. We had been preaching that Michigan was a great apple State, and that the apple orchards ought still to be in good condition; but they said: "That is all theory." We took the orchard of one man and proposed that we should take the profits and pay him, but at the end of the first season he was anxious to back out of the bargain, and we released him on the condition that he would continue the work. That demonstration did a great deal for the apple section of southeastern Michigan. That is not experimental work. We made no effort to make it experimental. In fact, I have never yet found it safe to trust an experiment to a man outside of the station if we intended to publish the result. I never will publish a result of an experiment that is not conducted solely by men in the employ of the station.

We are very much interested in supplies of phosphorus. Farmers have read in the Illinois bulletins what phosphorus will do in that State when derived from the finely ground rock; but you know we have a set of people coming from Ohio and other less civilized portions of the country who made our farmers believe that it was never safe to use phosphorus unless the rock had been treated with sulphuric acid, and we tried the experiment. We asked a farmer if he would not let us fairly test the matter in his section of the State. He furnished part of the fertilizer, and we furnished the rest. We did all the work. This farmer is now demonstrating to the farmers of Jackson County, Mich., the practicability of using the finely ground phosphate rock.

In the matter of animal industry we have certain difficulties environing the whole proposition which have made us reluctant to undertake any demonstration work whatever. In some parts of the State God has tested the powers of man severely by giving him a soil to work on which possesses nothing but sand and wind. In that particular part of the State live stock does not flourish. At the college we undertook some experiments to find out why the live stock does not flourish and we came to certain conclusions. The station went up in that country where a silo was unknown and built a silo, and I am here to say that the results of the demonstration were extremely satisfactory, financially, to at least three counties in the State of Michigan. On the station farm we do not consider it beneath our dignity to carry on considerable demonstration work. For instance, in the matter of legumes, in the matter of seed selection, we like to demonstrate on the station farm, because it is close at hand, what our station has done and what other stations are doing and have done in this matter; but we keep this work entirely divorced from the experiment-station work.

W. H. Jordan, of New York. I believe I fathered this subject which is before you by proposing it at the last meeting, and your discussion has taken somewhat the turn I expected it would. I have heard a definition here from Professor Corbett of what is demonstration work. Now, I expect we will have to give an arbitrary definition to that. Possibly I can illustrate what I mean. Some years ago the problem of red spot in cheese came up to us in the State of New York, and we had first to determine what red spot is. That was laboratory investigation. After determining the nature of the trouble, then we had before us the additional problem of how to get rid of the trouble, or control the trouble in the factories. We continued our work until we believed we had a method, and then went into the factories. To do what? To demonstrate the applicability of the method to commercial conditions. Now, according to Professor Corbett, that would be experimental work, because that was the last step in our solution of the problem. His definition, however, of demonstration would be this, I suppose, that after having taken the last step in a few factories, and showing the applicability of the method, if we were then to distribute ourselves to the various portions of the State and repeat that which we knew would happen, in a merely educational way, that that alone is demonstration work. Now, I did not have that restricted definition in mind when I proposed the problem. Demonstration work seems to me, as I suggested the problem, that last step of demonstrating in some form the final relation of a theory or a process to practice. Possibly that had better be included in experimental work, and let demonstration work cover merely that which is extension work or educational work. That is for us to determine. But the larger question which comes up to me is not how we shall define demonstration work, but where the limits of experiment station work shall be. That is the larger problem with us in New York. And the way in which we settle that question will be determined, I suspect, to some extent by the place that the matter of expediency has in our minds. Now, academically speaking, I hold that the proper function of the experiment station ceases when we have shown in a sufficiently extensive and practical manner, so as to leave no question, that our theory or our method is applicable to practice in a profitable way—or an unprofitable way, as the matter may be determined—and when we go beyond that we have stepped into the educational field, the field of merely teaching that which is known. Of course the experiment station men have been unable, by force of circumstances, to keep out of that field. I suspect; for I suppose that you all have the same experience that I have, that every known problem and question under the sun comes up to the station in the form of correspondence. I had a young man write me the other day not long ago saying, "I have purchased a farm"—and whether he had married a wife he did not say; I hope he had if he was a good man—"and I wish you would tell me the most profitable method of managing that farm; in other words, the crops I can raise, and the method of managing it that would give me the most money." A physician, who wished to expend some of his money made in practicing as a physician in playing with a farm, wrote saying that he had a farm in a certain portion of the State, equipped in a certain way, with so much stock and so many trees and so many hogs, and this, that, and the other, and that the farm was laid out in this, that, and the other way. "Now," he said, "I propose to make a certain amount of cider, and do a certain amount in dairying, and in certain other lines;" and he made a table in which he tabulated the lines of work which he would carry on; and on one side he wished me to put down what it would cost him to do that work, and on the other side what he would get out of it.

Now, with that sort of thing coming up to us and an expectant and anxious public, we may be pardoned, I suspect, if we overstep sometimes the proper lines of experiment-station work; but I believe we ought, because of the great problems that are pressing up against us, because of the limitations we all feel when we go before the public, because we know that our ignorance is a natural handicap to us in attempting to provide for the farmers—I believe we ought, to the very last degree of safety—to withhold the work of the station to investigating facts and showing that applicability, and leaving the extension work—what our friend Corbett would call the demonstration work—to the extension work of the university and the college. That is my policy, and I am going to hold to it as strongly as possible and leave to Cornell, possibly at the expense of the popularity of the Geneva institution, the extension work.

C. D. Smith. I want to call attention to one danger in this extension work, too, and that is this: We did a good thing for a township down near Detroit. But go to, now! Every other township in that section of the State insisted that the next year we should come over in their section and do likewise. And up in "The Thumb" of Michigan the station is now unpopular, because we do not come up there and buy a farm and make demonstration experiments. For that reason I agree with Director Jordan in regard to the colleges and insist that no money of the funds appropriated for the work of the station shall be used in the demonstration work. But the trouble with us, connected with the colleges, is that although we draw but one salary, we are expected to perform various functions, and our division ceases to be as clear as it ought to be, perhaps, because of the fact that we have to do two classes of work, being supplied with two different funds. But there is this danger, of unpopularity growing out of this work as well as popularity.

C. E. Thorne. I wish to make it plain that we regard our three or four test farms as adjuncts to our resources for scientific investigation and not as demonstration farms, but that this work which is being extended over the State through our department of cooperative experiments is in no sense scientific investigation, but that it is carrying to the townships a demonstration of the results of work which has been worked out at the main station or at these test farms. I would not know how to organize a demonstration of the effect of the use of fertilizers of two different compositions on a soil—or of one composition—if I did not lay off alongside of the tract which was to be treated with this fertilizer another tract to receive the treatment usual in that vicinity. I do not call that a scientific experiment or a method of scientific research; I do call it a demonstration. That is where we may differ as to definitions. We have done the same work in the orchard. As a pertinent example, our horticulturists at the beginning of the nineties went down into southern Ohio and persuaded a large apple grower to spray a part of his orchard with the then new Bordeaux mixture. He was unwilling to risk his whole orchard, and he sprayed about a third of it, and the contrast between the two portions was such that it figured out to him $500 that first season, and he has been an enthusiastic sprayer from that day to this, reporting his annual profit from spraying at $1,500 to $2,000 a year. He only became convinced through seeing alongside of his unsprayed trees the trees that had been sprayed under our direction. That was in no sense a scientific investigation. We certainly induced him to make what he might have called an experiment, but which was to us simply a demonstration of what we expected to be the outcome, and which was the outcome of his work.

Now, we expect to make each of the thousands of farms which we hope will take up this work which is being carried on by our department of cooperative experiments—a department which is supported entirely from State appropriations for that specific purpose and not at all from the Hatch fund—a point of demonstration, and a point, we hope, of education to the people around it; and to a certain extent we hope that these people will become experimenters. We hope that because no man can make progress in agriculture in our day unless he is more or less of an experimenter—I want to use another term: unless he has more or less of the spirit of scientific research—and we hope he will take up that work and carry it forward. But the work which he may do is a work of demonstration to himself and his neighbors of principles which we have previously worked out at the experiment station in connection with these adjunct farms.

C. G. Hopkins. We hardly feel that we can separate experiment from demonstration. I might say that if we go out on a certain area, and take 40 acres of corn, or a 40-acre tract of land, no matter if we have in mind simply experiment and discovery—which we never do have in mind—that becomes a demonstration to all the people in that section. We do not separate it and do not want to separate it. We feel that it is more economical to do the two things at once, and we do some things 100 or 200 miles away from the university that we possibly could do at the university in order not only to discover truth, but to demonstrate it to the people of that section.

Furthermore, while I can not quote exactly the language of the Hatch Act, I believe our State law is copied in part from it, and I know our State act says "for discovery and dissemination;" and we take any means of dissemination. If the best means of disseminating a truth is to go right in the field and demonstrate it and teach it to the people of that section, we use our State funds for that just as freely as we do for experiments in the laboratory; and I believe we use the United States funds just as freely. I will not state this positively, but I believe the Hatch Act says "dissemination" as well as "discovery."

W. H. Jordan. I just want to say another word. I get troubled sometimes over what I might speak of as the responsibilities of the institution I am in charge of. And I have had quite a good many arguments with my friends and colaborers in my State over what its responsibilities are for education or in the way of dissemination. It seems to me entirely clear that the function of the station is, first, to find out things, and then to see that they are properly placed before the public. But what constitutes properly placing them before the public? There is where the difficulty comes. I sometimes have troubles with the members of my board of control, like the rest of you. I had with one of them the other day, not a trouble, but a discussion. I used this illustration of red spot in cheese with him. I said: "It seems to me that when we have gone into factories to see we are right, and have demonstrated the applicability of the method we proposed, and then have placed that in simple terms, as we try to in our popular bulletins or leaflets, before every cheesemaker in the State of New York, we have done our duty." But his answer was: "The cheesemaker will not read your bulletin, and unless you go right under his nose, where he may see it, it will not become effective in his case."

Now, where is my responsibility? Am I responsible for the inertia, for the lack of alertness, for the stupidity of that man? What is my duty—to go all over the State, in every corner, and to place under the nose of every man a demonstration, or have I done my duty by him when I have made it possible for him, with ordinary alertness, with ordinary intelligence, and a business mind and impulses, to get hold of the whole thing? Why, gentlemen, if we accept the proposition that we are responsible for these inert fellows, where will our demonstrations end, and where is the fund? I know that Illinois has the biggest one in the United States. I do not mean that she shall have for a great while. Now, that is the proposition—where is the limit of responsibility? I am not taking sides on this, but I am placing before you what you all understand and appreciate as clearly as I do, I have no doubt, in regard to the situation. What shall our answer be? The best we can do, we can not get to a whole lot of men. We may place demonstration work in every county of the State where we are, and in several places in each county, and there will be a very large percentage of the farmers who will not see that demonstration work any more than they will read the bulletins.

H. J. WHEELER, of Rhode Island. If I understand it, there is no authority at all in the Hatch Act for disseminating anything in the line of agricultural information which has not been ascertained by investigation. I am very sure we have all been warned that not a cent of that money can legitimately, according to the strict interpretation of the Hatch Act, be used for anything in the line of demonstration work or in tabulating the results of material already known, but for publishing and disseminating what the individual stations may ascertain by experiments.

In our State we have had this under consideration. After something seems to have been settled on the station farm under our own conditions, the next thing is to ascertain by experiments whether the rest of the State is in the same condition or not, or whether this is generally applicable or not, and we do that by going into each county and selecting a number of representative fields and trying the matter there. When we have ascertained by experiment that the condition in each county is essentially that which we have found at our station the matter is then turned over to the extension department of the college, and it was my pleasure to propose the first raid on the State treasury to get money enough for such a demonstration department in the winter of 1892–93, and we now have such a demonstration department. After we have found out to our satisfaction that a certain thing is helpful, then the demonstration department of the college takes it up and prosecutes it in an educational way, and that is demonstration.

T. F. HUNT, of New York. I want to insist that the questions which farmers ask regarding how to manage their farms are perfectly proper. When a man writes to a station for some information on the principles of fertilizers his questions are answered willingly, because you have a bulletin on the principles of fertilizers which you can send to him. The only reason you may not answer questions regarding farm management is either you have not the information or because it is too much trouble to work out the problems. A question in economics is asked, and economics is just as important, and it ought to have just as much of the attention of the agricultural colleges, as chemistry, botany, physics, or any other science. The only trouble is that we know so little about it and give so little attention to it.

W. H. Jordan. I used those examples merely to illustrate the difficult things that come to us, not to make fun of the farmer. I believe it to be true, nevertheless, that such a question, for instance, as the first one I referred to, is an absolutely unanswerable question, because it is beyond the power and wisdom of any station director or any station employee to pick out business methods and the business course for anybody.

I commend what Professor Hunt said of the importance of the study of economics, and that we have very serious limitations in answering such questions, which we ought not to have very long.

H. J. Wheeler. When such general questions come in it seems to me that they should, so far as possible, be turned over to the demonstration department of the college to answer. I do not believe in turning the farmer down. It is the business of the college, and it should be the business of every college connected with these stations to have a demonstration department. Now, it is an unfortunate fact, perhaps, that the demonstration departments in all these colleges are not yet capable of answering all the questions that come in; and perhaps the stations are still answering some of them. The point I want to make is that just as fast as it is possible, and the right men are provided in the demonstration departments to answer these questions, all such questions should be diverted to that department, so as to leave the research end to its legitimate work.

C. G. Hopkins. I would like to raise the question whether the man who has discovered the facts and has them all in his hand had not better be a member of that other department, because he is best able to answer?

W. J. Spillman, of the U. S. Department of Agriculture. This is a subject which is very vital and intensely interesting to me. In the first place, I want to object to the use of the term "demonstration farm" for the demonstration station. A farm and an experiment station or a demonstration station and a demonstration farm are wholly different things. A farm is a business proposition. A station is a place for demonstrating or for experimenting, as I understand it.

I like Doctor Wheeler's suggestion that demonstration work be taken up seriously by the college, and that it belongs in the college rather than in the station; and yet the station men belong there a part of their time. There are many things they know better than anyone else. Without encroaching too much on their time, we ought to utilize their knowledge.

The necessity for demonstration work may be illustrated as follows: Here are certain things which Director Thorne shows to be true with respect to fertilizers on a certain type of soils and with certain crops. Farmers in distant parts of the State do not get a chance to see these results. Many of them do not even read the bulletins giving the results. Generally speaking, the farmer is not in the habit of getting his information by reading. Now it is legitimate, if we have the funds and the men, to establish a station where we can carry on a demonstration of that which has been shown to be true. But we must not confuse demonstrations of this character with demonstration farms, such as those we are conducting in conjunction with some of the southern stations. Now, a farm is a business proposition. Our demonstration farms are farms which are being run for the purpose of making so much money that they will attract public attention. They are not stations; they are not plats; they are farms. On one of these farms we are making a net profit of $75 an acre. The man who owns the farm is doing that. Professor Duggar will tell you that that farm has made an impression on the community in which it is located; and it is changing farm practice there in a remarkable manner. So I want to enforce that difference between a demonstration farm and a demonstration station or demonstration plat.

I wish that I had time to give you the reason we have developed certain types of farming in the South. That will get to you through the regular channels, sometime. On the particular farm referred to hogs are raised on alfalfa, but the rule is to feed the hogs 1 to 2 per cent of his live weight in corn per day. When the alfalfa is at its best the hog receives 1 per cent of his weight in corn a day; but if the alfalfa pasture runs low, it is 2 per cent. The hogs are ready for the southern market almost any time, but for the Chicago market they would need a little fattennig period later. They are producing the hogs at not over 2 cents per pound, and they sell them at 5 cents. With corn at 80 cents a bushel, they made $75 an acre for the alfalfa. That is a demonstration farm for which Professor Duggar and M. A. Crosby of my office and myself are responsible.

I believe that it was Director Jordan who spoke about the advisability of a man assuming the responsibility of advising regarding the business management of a farm. I just want to offer this suggestion in that connection, and one or two of my colleagues in the Department have made the same suggestion. I should hesitate to prescribe medicine for a sick man, but I know people who would not; people who have paid particular attention to that thing, and make it their business. Most experiment station men have not made a special study of the business side of farming, and perhaps they should not; because we need some men who are going to dig deep into nature and learn new facts, and a man who is busy and loading himself up with the responsibilities of the business management of farms is going to find his investigational work seriously interfered with; but it is possible for a man to devote himself to the business management of farms, and you will find that there are principles involved there, just as there are in the application of fertilizers. There are principles involved in the business management of the farm which a few years' study will develop, so that a man will, if he devotes his time to it, be able to outline a cropping system for the farmer. To do that a man must study; a man must first become familiar with the types of farming that have proven particularly successful in a given section of the country. That can be done and is being done. When we have learned that, we find that the principles are comparatively simple. We find, too, that the farmer, the man who is making a preeminent success, who is getting rich off of a small farm, is almost invariably a book farmer. I have not found a single exception to that yet. But the converse of that is not true. I have found some book farmers who are not getting rich on their farms. By book farmers I mean they are men who understand a good deal of the science of agriculture, and are making use of that science in their work.

Now, the office of farm management burdens itself with the business side of farming. We have found in our study of farms and farmers that one of the most important phases of the business management of the farm is the understanding and application of scientific principles in the production of crops, in the handling of soil, and in the feeding and management of live stock. We are making an attempt to compel the farmer to adopt scientific principles. The results you men are securing in your investigations in the experiment stations we are trying to force the farmer to adopt in his work. Now, we find through the country, in some sections much more than others, that there are farmers who have adopted the results of your studies, and have worked out that important problem, fully as difficult in many cases as your work in discovering it was, of how to take advantage of that knowledge and to make money from it on the farm. Take Mr. Detrick, for instance, about whom so much has been written. There was a man who had worked out the important problem of how to utilize scientific knowledge on the farm; and I confess that I learned more from that man in one day about the application of scientific principles in farming, and the business features of farming, than I had learned in two years previously. His was a phenomenal case; but his was not the only one.

Although a few years ago I felt that it was hardly fair to say that there was such a thing as agricultural science, I am now prepared to say that there is such a thing as agricultural science, and to defend that opinion. Now, this body of knowledge has been gathered from two sources. One is the work that has been done by experiment station men. A large body of knowledge has been obtained by careful scientific inquiry, and a good deal of it is classified, arranged, and usable. On the other hand, we sometimes overlook the fact that every farm is an experiment station, though an experiment station is not and should not be a farm. But the farm must be an experiment station. And every farmer in America is an experiment station man and is investigating. It is true that he is hewing wood with a dull ax frequently, and he is sawing with a broken-toothed saw; but he gets his log sawed in two sometimes.

Now, no small part of this thing we call agricultural science comes from the gathering up and sifting of the experience of the farmer. And now I want to say this. Some of you experiment station men may differ with me here. But you let me study carefully the work of one hundred farmers, and let me draw my own conclusions from their experience. I would like to have their conclusions, too, although I usually do not care very much for them. Still, I like to get them, because they are frequently exceedingly suggestive and quite frequently correct.

You let me draw my conclusions from the experience of 100 men—if I can get the facts of their experience—and I will come pretty near getting the theory from their experiences, whether they had any idea of carrying on experiments or not.

I have found a number of farmers who, in the handling of barnyard manure, used enough absorbent to hold all the liquid along with the solid, and who have developed a system by which they carry the manure to the field and spread the manure as soon as it is made—every day or every two days. Now, the farmer has not carried on any scientific investigation to find out whether by that practice he loses a lot of plant food, and he does not know; but, gentlemen, the farmers who are doing that are producing the largest crops of any men in the United States.

Now, I contend that the fact that the men who were doing that, and without the use of any commercial fertilizers, are sometimes producing crops three times as large as we expect a good farmer to produce, proves that that practice is perhaps the best practice, where it is feasible; and I have drawn that conclusion from the practice of those farmers. I may be wrong in that, but I have done it; and I claim that we have gotten a large part of this thing we call agricultural science from a study of farm practice. By the way, we adopted at one time, and decided to call the office which I represent by the name of the office of farm practice; at the present time the major part of the work of that office is the study of farm practice. That study is not a superficial study, but it is a serious attempt to formulate important principles from the experience of farmers. In most cases each man takes up the study of a single phase of farming. In some cases the field of study is more general.

For instance, one of our men this past season has been studying the cropping systems in vogue in certain parts of the country. He finds that there are certain farms which are preeminently successful, making large sums of money, and he gives especial attention to the cropping systems on those farms, and the methods used for maintaining the fertility of the soil. As a result of such study we are ready now in many instances to answer the inquiries of the farmer who writes to us and says, "I am running a little dairy farm in such and such a State and should like some advice about growing feed for my cows." First, we ask him about his soil, and get all the information it is possible to get from him about his conditions and equipment for work. If we do not understand his conditions we send a man to study the situation. Then, after we understand his conditions, in many cases we do not hesitate to formulate a cropping system and tell the dairyman what to grow, how much to grow, and how to feed it; and we do that.

Now, I wish that I had time to outline to you in full the work of the office of farm management. I know there is an inquiry in your minds in regard to it, and I am anxious to answer the inquiry as far as I can. And I am anxious, too, that in this work we shall be helpful to you people who are engaged in your own States in scientific investigation. I want to say this, that there is one gap in our system of investigation in this connection. It is one that is being bridged, and one that the office of farm management is intended to bridge. You all know what it meant to teach agriculture before we had experiment stations, or rather you all know it did not mean much of anything. After our experiment stations had been running five years the teaching of agriculture began to assume a meaning. That means that these experiment stations have been gathering facts that have a direct relation to the business side of farming. Now we have our experiment stations delving into nature for facts and principles, and getting them, too. The original intention was to get these facts and principles and publish them, and that is the method that has generally been adopted. We have found, as we might perhaps have reasoned out would be the case, that most of the farmers do not get their information by reading, and yet once in a while here and there is found a bright farmer, an educated man, usually one who has studied and got the lessons we have offered him. The average farmer has not done that at all, and now we need some means of bringing our lesson to the average farmer.

We must carry this information to the farmer in a way which appreciates the farmer's limitations. Here Professor Duggar and I established a farm. We planned a system of management for that farm. The farmer who owned it followed out the instructions in a very accurate manner. He got results that were astonishing, even to those of us who had planned the work. We first announced a year ago that we would hold a farmers' institute at this farm. Unfortunately, a slow train prevented me from getting to the institute, but Professor Duggar was there, and there were a thousand farmers at that institute. The crowd could not be handled, it was so big. This summer we held another institute on this farm, and instead of announcing the fact publicly we sent out 150 invitations to selected farmers, and all responded. The meeting was held in a beautiful grove on the farm, where from the platform we could see the hogs in the alfalfa field. Between us and that field the owner of the farm was building a hay barn. Formerly he had bought his hay from Ohio and Indiana and Illinois. Now he was raising more hay than he had ever raised. In my presence a local farmer offered him $20 a ton for some of that hay. He would not sell it, because he would simply have to buy more.

Those farmers sat with their mouths open for two hours and listened to the discussions of the experience on that farm. That was a farm, and not demonstration plats; and I believe that as the result of that little farm there will be many thousands of acres of alfalfa sown in that neighborhood. The danger is that we may overencourage the industry. That is a single-crop country, and whenever the farmers cut loose from cotton the tendency always is for them to rush pellmell into something else and to overdo it. I am using this as an illustration of the value of a means of getting our illustrations before the farmer. What did we do on that farm? Professor Duggar and Professor Richeson—the farm is located right by the side of the Canebrake Experiment Station—had shown previously that alfalfa would grow on that black waxy soil beautifully. We just went outside of the experiment station fence to show the farmer how to make money out of the experiment, and although they had been watching that alfalfa grow there for a long time it was only after we had demonstrated that there was money in alfalfa, and showed them how to get it out, that they did anything with it themselves. Now thousands of acres of alfalfa are being sown. That is only one illustration. I could give you others. I believe in this demonstration work. It is the work that is to fill the gap that exists in our methods of investigation and dissemination of knowledge.

C. D. Smith. Do not let us forget the newspapers as a means of dissemination. If I were asked to name the force in Michigan that is ahead of all others, I would hesitate to name any other influence before that of the rural press; and the cordial relation between the press and the station has doubled the efficiency of our work.

H. P. Armsby, of Pennsylvania. As I have listened to this extremely interesting and stimulating discussion I have been thinking of a matter which is perhaps a little aside from that which we have been considering, and yet is suggested by this: In a certain old book which we sometimes read it is written, "Woe unto you when all men speak well of you." Seriously, I think I can see a somewhat serious danger before our experiment stations on that line. Some of us know, if we only know by reading, something of the expectations that were formed when these institutions were first founded, back in the sixties, and we know something, also, of the disappointment which those expectations met with and of the sort of "middle ages" which ensued, when the agricultural colleges were in a good deal of disrepute, when they lost the confidence of the farmer, very largely because he had been led to form exaggerated expectations of what they could do for him. Now, the experiment stations have been gradually building up and securing the confidence of the farmers of the country, and I fear we are coming now into much the same position as the colleges were in originally, where the farmers expect almost everything of the station, and I think perhaps some of our friends have been a little injudicious in what they have said about the station; I think perhaps they have exaggerated what the stations have accomplished. They say that the stations are digging out the fundamental principles of agricultural science and building up materials for the instruction of the colleges; and so they are. But it is easy, I think, to exaggerate the actual contribution that the agricultural experiment stations have made thus far to agricultural science. I do not mean to belittle it, but it is easy to exaggerate it and its influence on the farmers of the country. I do not mean by this to throw cold water on this investigation work or demonstration work; but I think we should bear this in mind, that we should not lead the farmer to expect that the agricultural millenium is coming in the near future, or has come. That we should be careful not to foster in the mind of the farmer the idea that the agricultural experiment station and college are the two crutches on which he is to make progress through the world. The one thing, it seems to me, which the experiment station and the agricultural college call upon the farmer for is, not less thought, but more. It seems to me that unless we teach him to think for himself, to work out his own problems, with our help where we can help him: that unless we set him to thinking for himself and working out his own problems and applying the principles, we are not doing him the real service that we ought to. I throw that out as a suggestion.

W. H. Jordan. I would like to emphasize, if I am able to do so, what Professor Armsby has just said. I have said many times in my life that there is danger of trying to do too much for the farmer, and giving him a slant of mind that leads him to think that he is dependent upon some other agency than himself for his success.

To revert a little to what advice we may give: Not long since a group of gentlemen interested in a large agricultural operation, namely, gentlemen who were producing crops which they themselves were canning in factories owned by themselves, called on me and my associates for advice. In the first place, they wished to purchase the materials and make their own fertilizers. There were some very definite things that could be said to them about that, and I sat down with them and spent an hour talking about that side of their work. They proposed to raise large areas of beans, and the question of disease was a possibility; and I sent them to the plant pathologist of the experiment station. They were having certain troubles in their canning operations, and I sent them to the bacteriologist. There were certain other problems in their work, and I sent them to the experts of the station having knowledge of them. I believe that in doing that we have done pretty nearly all that it is possible to do for that body of men. It still remained for them to take the facts given by our experts and coordinate them into their system of business, and I doubt whether with any man you can go much further than that. His temperament, his peculiar environment, which you must study in great detail before you can advise him definitely, are factors which must enter into your calculations; and even if you had a farm economist—and I wish there was one attached to each station for work along that line—he would have his limitations in regard to what a man can do in his business.

W. J. Spillman. I appreciate very fully the force of the suggestions that Professor Armsby and Doctor Jordan have just made. We can divide farmers into three classes, one consisting of those who have the idea that the experiment station is a theoretical sort of thing that has nothing for him, and that class is pretty numerous in all parts of the country. Another is a large class, consisting of those who never heard of the experiment station, and this class is more numerous than we think. Then there is another class of farmers who have a very exaggerated idea of the importance of the station for them, or rather an exaggerated idea of what the station can do for them. I agree with the suggestion that it is not well to encourage too great expectations. At the same time, by a conservative man, who is a farm economist, who has made a special study of types of farming and systems of farm management, it is easy to be of enormous service to the farmer. Now, it is my judgment that we can do more to increase our agricultural products and the results of the work of the farmer by giving attention to the cropping system, the system of management, the business methods of the farm, and improving them, than we can in any other immediate way.

At the risk of trespassing on your patience, I want to give you just one more illustration. Down in Georgia there is a dairy farm of 135 acres of land, with 90 cows and the necessary young stock—high-grade cows, some of them making 500 pounds of butter a year. This farm is owned and managed by the cashier of a bank, a man who could give me the cost, down to a cent, of everything; who kept as accurate a set of books on his farm as he did for the bank. The gross income for the year before had been $41 per acre. His net income was $23 an acre. His management of his cows I considered to be ideal, and, although I am a dairy farmer, I was not able to think of any improvements he could make in his system of managing his cows. But I found that man utilizing two-thirds of his land for four months in the year growing crops for his cows. It is true that he was growing phenomenally large crops, but he was utilizing only two-thirds of his land for four months of each year for growing feed. On the other third he was growing straw for bedding. We have made ourselves familiar with the possibilities of farming in that section, and it was plain that he was using a poor cropping system. We suggested a better system. He said nothing. He was a conservative, careful, thinking man. Three weeks later we received a letter from him asking us to outline that system on paper. This was done. About a month later he wrote again, saying: "I have decided to adopt the system you have suggested in full, and you are invited to make suggestions upon any feature of my farming at any time a suggestion occurs to you." He has that system now about half in operation. The gross income has been raised the first year from $41 to $67 per acre as the result of an improved cropping system.

Now, the point I want to make is this: That while there is danger, and I realize it as fully as any of you, of getting the farmer to rely too much upon us, there is an opportunity which is unexcelled of improving agricultural practice in this country by studying the farmer and his immediate problems, and making recommendations where we understand the conditions.

We get letters from hundreds of farmers—we have gotten as many as 59 of these letters in two days—asking us to plan cropping systems. To most of those letters we reply, "We can not help you; we do not know your local conditions." But many of them come from sections where we do know the conditions, and when such is the case we give the information. There are many instances where this information has been utilized in largely increasing the income of the farm. I believe it is possible, by putting enough men on work of this kind, to increase very materially the product of the land in this country, by aiding the farmer to utilize what you men have already discovered and what other farmers have discovered. Of course it is difficult to prophesy, but I think it is possible to double the agricultural products of this country by that means. Now, it may be assuming too much responsibility, but I believe we are justified in doing it. It is true it calls for conservatism. It is true that in this work we are advertising your work. We are teaching people to believe great things of you, and we may be doing some harm along with the good we do.

W. R. Dodson, of Louisiana, for the programme committee, recommended that the subject for discussion by the next convention be "Animal nutrition," and that the committee on that programme be H. P. Armsby, C. F. Curtiss, and the secretary.

The recommendation was approved, and the programme committee named was instructed to select a second topic.

Thereupon the section adjourned sine die.

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THE AGRICULTURAL EXPERIMENT STATIONS.

- Alabama—
  - College Station: *Auburn.* J. F. Duggar.[a]
  - Canebrake Station: *Uniontown.* J. M. Richeson.[b]
  - Tuskegee Station: *Tuskegee.* G. W. Carver.[a]
- Alaska—*Sitka:* C. C. Georgeson.[c]
- Arizona—*Tucson:* R. H. Forbes.[a]
- Arkansas—*Fayetteville:* W. G. Vincenheller.[a]
- California—*Berkeley:* E. J. Wickson.[d]
- Colorado—*Fort Collins:* L. G. Carpenter.[a]
- Connecticut—
  - State Station: *New Haven.* E. H. Jenkins.[a]
  - Storrs Station: *Storrs.* L. A. Clinton.[a]
- Delaware—*Newark:* A. T. Neale.[a]
- Florida—*Lake City:* P. H. Rolfs.[a]
- Georgia—*Experiment:* R. J. Redding.[a]
- Hawaii—
  - Federal Station: *Honolulu.* J. G. Smith.[c]
  - Sugar Planters' Station: *Honolulu.* C. F. Eckart.[a]
- Idaho—*Moscow:* H. T. French.[a]
- Illinois—*Urbana:* E. Davenport.[a]
- Indiana—*Lafayette:* A. Goss.[a]
- Iowa—*Ames:* C. F. Curtiss.[a]
- Kansas—*Manhattan:* J. T. Willard.[a]
- Kentucky—*Lexington:* M. A. Scovell.[a]
- Louisiana—
  - State Station: *Baton Rouge.*
  - Sugar Station: *Audubon Park, New Orleans.*
  - North Louisiana Station: *Calhoun.* W. R. Dodson.[a]
- Maine—*Orono:* C. D. Woods.[a]
- Maryland—*College Park:* H. J. Patterson.[a]
- Massachusetts—*Amherst:* W. P. Brooks.[a]
- Michigan—*Agricultural College:* C. D. Smith.[a]
- Minnesota—*St. Anthony Park, St. Paul:* W. M. Liggett.[a]
- Mississippi—*Agricultural College:* W. L. Hutchinson.[a]
- Missouri—
  - College Station: *Columbia.* H. J. Waters.[a]
  - Fruit Station: *Mountain Grove.* P. Evans.[a]
- Montana—*Bozeman:* F. B. Linfield.[a]
- Nebraska—*Lincoln:* E. A. Burnett.[a]
- Nevada—*Reno:* N. E. Wilson.[d]
- New Hampshire—*Durham:* W. D. Gibbs.[a]
- New Jersey—*New Brunswick:* E. B. Voorhees.[a]
- New Mexico—*Agricultural College:* L. Foster.[a]
- New York—
  - State Station: *Geneva.* W. H. Jordan.[a]
  - Cornell Station: *Ithaca.* L. H. Bailey.[a]
- North Carolina—*Raleigh:* B. W. Kilgore.[a]
- North Dakota—*Agricultural College:* J. H. Worst.[a]
- Ohio—*Wooster:* C. E. Thorne.[a]
- Oklahoma—*Stillwater:* J. Fields.[a]
- Oregon—*Corvallis:* J. Withycombe.[a]
- Pennsylvania—*State College:* H. P. Armsby.[a]
- Porto Rico—*Mayaguez:* D. W. May.[c]
- Rhode Island—*Kingston:* H. J. Wheeler.[a]
- South Carolina—*Clemson College:* J. N. Harper.[a]
- South Dakota—*Brookings:* J. W. Wilson.[a]
- Tennessee—*Knoxville:* H. A. Morgan.[a]
- Texas—*College Station:* John A. Craig.[a]
- Utah—*Logan:* P. A. Yoder.[a]
- Vermont—*Burlington:* J. L. Hills.[a]
- Virginia—*Blacksburg:* A. M. Soule.[a]
- Washington—*Pullman:* E. A. Bryan.[a]
- West Virginia—*Morgantown:* J. H. Stewart.[a]
- Wisconsin—*Madison:* W. A. Henry.[a]
- Wyoming—*Laramie:* B. C. Buffum.[a]

[a] Director. [b] Assistant director. [c] Special agent in charge. [d] Acting director.

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 165.

A. C. TRUE, Director

PROCEEDINGS

OF THE

TENTH ANNUAL MEETING

OF THE

AMERICAN ASSOCIATION OF FARMERS' INSTITUTE WORKERS,

HELD AT

WASHINGTON, D. C., NOVEMBER 9–11, 1905.

EDITED BY

W. H. BEAL and JOHN HAMILTON,
For the Office of Experiment Stations,

AND

G. C. CREELMAN,
For the Association.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

OFFICIALS IN CHARGE OF FARMERS' INSTITUTES.

Alabama.—C. A. Cary, professor of veterinary science, Polytechnic Institute, Auburn; G. W. Carver, director Agricultural Experiment Station, Tuskegee.

Alaska.—C. C. Georgeson, Agricultural Experiment Station, Sitka.

Arizona.—R. H. Forbes, director Agricultural Experiment Station, Tucson.

Arkansas.—J. N. Tillman, president University of Arkansas, Fayetteville.

California.—E. J. Wickson, superintendent of Farmers' Institutes, University of California, Berkeley; D. T. Fowler, conductor of Farmers' Institutes in central and northern California, Berkeley; J. B. Neff, conductor of Farmers' Institutes in southern California, Anaheim; W. T. Clark, assistant superintendent of Farmers' Institutes, Berkeley.

Colorado.—W. L. Carlyle, dean of School of Agriculture, State Agricultural College, Fort Collins; Fred. P. Johnson, assistant superintendent of Farmers' Institutes, Denver.

Connecticut.—James F. Brown, secretary State Board of Agriculture, North Stonington; J. G. Schwink, jr., secretary Connecticut Dairymen's Association, Meriden; H. C. C. Miles, secretary Connecticut Pomological Society, Milford.

Delaware.—Wesley Webb, secretary Board of Agriculture, Dover; Arthur T. Neale, director of Agricultural Experiment Station, and superintendent of institutes for Newcastle County, Newark.

Florida.—C. M. Conner, professor of agriculture, University of Florida, Lake City.

Georgia.—H. C. White, president State College of Agriculture, Athens; Harvie Jordan, field agent in charge of Farmers' Institutes, 920 Empire Building, Atlanta.

Hawaii.—J. G. Smith, Agricultural Experiment Station, Honolulu.

Idaho.—H. T. French, director Agricultural Experiment Station, Moscow.

Illinois.—Frank H. Hall, secretary Illinois Farmers' Institutes, Aurora.

Indiana.—W. C. Latta, professor of agriculture in Purdue University, Lafayette.

Iowa.—J. C. Simpson, secretary State Board of Agriculture, Des Moines.

Kansas.—J. T. Willard, director Agricultural Experiment Station, Manhattan; J. H. Miller, assistant superintendent of Farmers' Institutes, Manhattan.

Kentucky.—Hubert Vreeland, commissioner of agriculture, Frankfort.

Louisiana.—Charles Schuler, commissioner of agriculture and immigration, Baton Rouge.

Maine.—A. W. Gilman, commissioner of agriculture, Augusta.

Maryland.—W. L. Amoss, director Farmers' Institutes, Benson.

Massachusetts.—J. L. Ellsworth, secretary State Board of Agriculture, Boston.

Michigan.—L. R. Taft, superintendent of Farmers' Institutes, Agricultural College.

Minnesota.—O. C. Gregg, director Farmers' Institutes, Lynd.

Mississippi.—J. C. Hardy, president Agricultural and Mechanical College, Agricultural College.

Missouri.—Geo. B. Ellis, secretary State Board of Agriculture, Columbia.

Montana.—F. B. Linfield, director Agricultural Experiment Station, Bozeman.

Nebraska.—E. A. Burnett, director Agricultural Experiment Station, Lincoln.

Nevada.—J. E. Stubbs, president Nevada State University, Reno.

New Hampshire.—N. J. Bachelder, secretary State Board of Agriculture, Concord.

New Jersey.—Franklin Dye, secretary State Board of Agriculture, Trenton.

New Mexico.—Luther Foster, president Agricultural and Mechanical College, Agricultural College.

New York.—F. E. Dawley, director Farmers' Institutes, Fayetteville.

North Carolina.—S. L. Patterson, commissioner of agriculture, Raleigh; Tait Butler, professor veterinary science, College of Agriculture and Mechanic Arts, field agent, Raleigh.

North Dakota.—E. E. Kaufman, deputy commissioner of agriculture, Bismarck.

Ohio.—W. W. Miller, secretary State Board of Agriculture, Columbus.

Oklahoma Territory.—C. A. McNabb, secretary State Board of Agriculture, Guthrie.

Oregon.—J. Withycombe, director Agricultural Experiment Station, Corvallis.

Pennsylvania.—A. L. Martin, deputy secretary of agriculture, Harrisburg.

Porto Rico.—D. W. May, Agricultural Experiment Station, Mayaguez.

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South Carolina.—J. N. Harper, director Agricultural Experiment Station, Clemson College.

South Dakota.—M. F. Greeley, superintendent of Farmers' Institutes, Gary.

Tennessee.—W. W. Ogilvie, commissioner of agriculture, Nashville.

Texas.—J. W. Carson, director Farmers' Institutes, College Station.

Utah.—P. A. Yoder, director Agricultural Experiment Station, Logan.

Vermont.—George Aitken, secretary State Board of Agriculture, Woodstock.

Virginia.—G. W. Koiner, commissioner of agriculture, Richmond; A. M. Soule, director Agricultural Experiment Station and secretary Virginia State Farmers' Institute, Blacksburg.

Washington.—E. A. Bryan, president Agricultural College and School of Science, Pullman; E. E. Elliott, professor of agriculture, Washington Agricultural College, field agent in charge of institutes, Pullman.

West Virginia.—H. E. Williams, assistant secretary of agriculture, Sunlight.

Wisconsin.—G. B. McKerrow, director Farmers' Institutes, Madison.

Wyoming.—B. C. Buffum, director Agricultural Experiment Station, Laramie

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OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 165.

A. C. TRUE, Director.

PROCEEDINGS

OF THE

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For the Office of Experiment Stations,

AND

G. C. CREELMAN,
For the Association.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

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D. J. Crosby, M. S., *Agricultural Education.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., January 15, 1906.

Sir: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 165 of this Office, a report of the proceedings of the tenth annual meeting of the American Association of Farmers' Institute Workers, held at Washington, D. C., November 9-11, 1905.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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RETIRING OFFICERS OF THE ASSOCIATION.

President.

J. C. Hardy, Agricultural College, Miss.

Vice-President.

E. A. Burnett, Lincoln, Nebr.

Secretary-Treasurer.

G. C. Creelman, Guelph, Canada.

Executive Committee.

The President and the Secretary-Treasurer, *ex officio;* J. G. Lee, of Louisiana; F. H. Hall, of Illinois; L. A. Clinton, of Connecticut.

OFFICERS CHOSEN AT THE WASHINGTON MEETING.

President.

G. C. Creelman, Gueiph, Canada.

Vice-President.

W. W. Miller, Columbus, Ohio.

Secretary-Treasurer.

John Hamilton, Washington, D. C.

Executive Committee.

The President and the Secretary-Treasurer, *ex officio;* J. G. Lee, of Louisiana; F. H. Hall, of Illinois; W. L. Amoss, of Maryland.

DELEGATES AND VISITORS IN ATTENDANCE AT WASHINGTON.

Aitken, G., Woodstock, Vt.
Allen, E. W., Washington, D. C.
Amoss, W. L., Benson, Md.
Beal, W. H., Washington, D. C.
Breen, Miss Mary C., Washington, D. C.
Brown, James F., North Stonington, Conn.
Brown, Mrs. James F., North Stonington, Conn.
Burnett, E. A., Lincoln, Nebr.
Butler, Tait, Raleigh, N. C.
Cary, C. A., Auburn, Ala.
Charlton, J. A., Toronto, Canada.
Charlton, Mrs. J. A., Toronto, Canada.
Coffey, G. N., Washington, D. C.
Cook, H. E., Denmark, N. Y.
Cook, W. M., Camden, Ohio.
Creelman, G. C., Guelph, Canada.
Critchfield, N. B., Harrisburg, Pa.
Daish, W. M., Washington, D. C.
Daniels, H. O., Middletown, Conn.
Davis, F. L., North Pomfret, Vt.
Dexter, W. H., Takoma Park, D. C.
Dodson, W. R., Baton Rouge, La.
Drury, J. H., Chaney, Md.
Duncan, D. I., Selma, Ind.
Eidsness, L. M., Washington, D. C.
Elliott, A., Galt, Ontario, Canada.
Ellsworth, J. L., Boston, Mass.
Freeman, F., Willows, Cal.
French, H. T., Moscow, Idaho.
Garvin, J. B., Charleston, W. Va.
Goodrich, C. L., Glenndale, Md.
Gray, Miss Lillian D., Toronto, Ontario, Canada.
Gregg, O. C., Lynd, Minn.
Hall, Frank H., Aurora, Ill.
Halsey, Mrs. S. W., Washington, D. C.
Hamilton, John, Washington, D. C.
Harlow, G. A., Alexandria, Va.
Harper, J. N., Clemson College, S. C.
Hays, W. M., Washington, D. C.
Hughes, Mrs. A. W., Washington, D. C.
James, E. J., Urbana, Ill.
Kahler, A. J., Hughesville, Pa.
Kaufman, E. E., Bismarck, N. Dak.
Kaufman, Mrs. E. E., Bismarck, N. Dak.
Kennedy, P. B., Reno, Nev.
King, W. M., Glencarlyn, Va.
King, Mrs. W. M., Glencarlyn, Va.
Kydd, W. F., Simcoe, Ontario, Canada.
Latta, W. C., Lafayette, Ind.
Lee, J. G., Baton Rouge, La.
Lee, Miss Mary E., Westerville, Ohio.
Lloyd, E. R., Agricultural College, Miss.
Lloyd, Mrs. E. R., Agricultural College, Miss.
Mackintosh, R. S., Auburn, Ala.
Maddock, Miss Blanche R., Guelph, Ontario, Canada.
McDonnell, Henry, College Park, Md.
Mead, Elwood, Washington, D. C.
Miles, H. C. C., Milford, Conn.
Miller, H. H., Guelph, Ontario, Canada.
Miller, W. W., Columbus, Ohio.
Patterson, James K., Lexington, Ky.
Patterson, H. J., College Park, Md.
Putnam, G. A., Toronto, Ontario, Canada.
Rankin, F. H., Urbana, Ill.
Rankin, Mrs. F. H., Urbana,
Readey, J. C., Charlottetown, Prince Edward Island, Canada.
Reid, S. E., Charlottetown, Prince Edward Island, Canada.
Rose, Miss Laura, Guelph, Ontario, Canada.
Schwink, J. G., jr., Meriden, Conn.
Scovell, M. A., Lexington, Ky.
Simonds, J. F., Riverdale, Md.
Sipe, Miss Susan B., Washington, D. C.
Smith, Miss Agnes B., Hamilton, Ontario, Canada.
Soule, A. M., Blacksburg, Va.
Stadtmueller, F. H., Elmwood, Conn.

Stroup, H., Paris, Ark.
Symons, Thomas B., College Park, Md.
Taft, L. R., Agricultural College, Mich.
Taliaferro, W. T. L., College Park, Md.
Tillman, J. N., Fayetteville, Ark.
Tower, E. E., Hopbottom, Pa.
True, A. C., Washington, D. C.
Utter, Delbert, Lake Beulah, Wis.
Vincenheller, W. G., Fayetteville, Ark.
Vreeland, Hubert, Frankfort, Ky.
Vreeland, Mrs. Hubert, Frankfort, Ky.
Webb, Wesley, Dover, Del.
Weems, Franklin, Upper Marlboro, Md.
Wheeler, C. F., Washington, D. C.
Wilson, Hon. James, Washington, D. C.
Wyman, B. F., Sycamore, Ill.
Yoder, P. A., Logan, Utah.

CONSTITUTION OF THE ASSOCIATION.

Article I.

NAME.

This organization shall be known by the name of The American Association of Farmers' Institute Workers.

Article II.

OFFICERS.

The officers shall consist of a president, vice-president, and secretary-treasurer, to be elected by ballot.

Article III.

MEMBERSHIP.

Any active worker in the farmers' institutes in the United States and Canada may become a regular member of this association on payment of the annual dues, and is entitled to one vote. A delegate member representing the State Farmers' Institute organization shall be admitted from each State and Province, on compliance with the by-laws, and shall be entitled to cast five votes on any question: *Provided*, That the annual membership dues of the person shall be $1 and that of the State $5. Also the United States Department of Agriculture and the Office of Experiment Stations of that Department shall each be entitled to representation in the association, with the full privileges of delegate membership.

Article IV.

DUES.

The annual dues of delegate members shall be $5 for six representatives of each State. The annual dues of members not delegates shall be $1.

Article V.

TERM OF OFFICE.

The term of office of the officers of this association shall be for one year from the 1st day of January next following their election, or until their successors are elected.

Article VI.

DUTIES OF OFFICERS.

The duties of the officers of this association shall be those usually performed by officials of like rank in similar associations.

Article VII.

ASSOCIATE MEMBERS.

Honorary members of this organization may be elected from time to time upon the presentation of their names by some member of the association and upon their receiving the votes of at least two-thirds of the members present.

ARTICLE VIII.

POWER OF HONORARY MEMBERS.

Honorary members shall be entitled to sit in all of the sessions of the association and to take part in all discussions, but shall have no vote.

ARTICLE IX.

BY-LAWS.

This association shall have power to make by-laws from time to time not inconsistent with this constitution.

ARTICLE X.

EXECUTIVE COMMITTEE.

There shall be an executive committee, consisting of the president and the secretary-treasurer of this association, ex officio, and three other members, to be elected annually by ballot, who shall meet at the call of the president and have charge of such matters of business relating to the association as shall be necessary to attend to in the interval between the annual meetings, and it shall be their duty to report such action as they may take to the next regular meeting of the association.

ARTICLE XI.

CHANGE IN CONSTITUTION.

This constitution shall not be changed except by a vote of two-thirds of the members at a regular annual meeting held one year from the date on which the proposed alteration or amendment has been first presented.

BY-LAWS.

(1) The time of meeting of this organization shall be fixed by the association.
(2) Order of business:
    1. Calling the roll of membership.
    2. Reading of minutes of previous meeting.
    3. Admission of new members.
    4. Reports of committees.
    5. Election of officers.
    6. Appointment of committees.
    7. Unfinished business.
    8. New business.
    9. Adjournment.

PROGRAMME OF THE WASHINGTON MEETING.

Thursday, November 9, 1905, 2 p. m.

1. Address of welcome—James Wilson, Secretary of Agriculture of the United States, Washington, D. C.
2. Reply to address of welcome—C. C. James, Deputy Minister of Agriculture, Toronto, Canada.
3. President's address—J. C. Hardy, Agricultural College, Miss.
4. Discussion of president's address—George McKerrow, Madison, Wis.
5. Roll call by States and Provinces.

Thursday, November 9, 8 p. m.

6. Five-minute reports from the several States and Provinces. These reports must be written and handed to the secretary, and should contain a synopsis of the work of the past year only, including—
    - (*a*) Number of meetings held.
    - (*b*) Amount of money spent.
    - (*c*) Number of speakers employed.
    - (*d*) General plan of campaign.
    - (*e*) New lines of work inaugurated and carried out.

Subjects for Discussion at Succeeding Sessions.

7. Consolidated schools—W. M. Hays, Assistant Secretary of Agriculture, Washington, D. C.
8. Institute organization and methods—L. R. Taft, Agricultural College, Mich.; J. B. Thoburn, Guthrie, Okla.; E. E. Kaufman, Bismarck, N. Dak.
9. Institute lecturers—Tait Butler, Raleigh, N. C.; L. A. Clinton, Storrs, Conn.; C. C. James, Toronto, Canada.
10. Cooperation with other educational agencies—F. H. Hall, Aurora, Ill.; G. A. Putnam, Toronto, Ontario; W. C. Latta, Lafayette, Ind.
11. Movable schools—J. Hamilton, Washington, D. C.; A. L. Martin, Harrisburg, Pa.; J. C. Hardy, Agricultural College, Miss.
12. Boys' and girls' institutes—F. H. Rankin, Urbana, Ill.; G. B. Ellis, Columbia, Mo.; E. A. Burnett, Lincoln, Nebr.
13. Cooperation with the National Department of Agriculture—F. E. Dawley, Fayetteville, N. Y.; W. L. Amoss, College Park, Md.; K. L. Butterfield, Kingston, R. I.

PROCEEDINGS OF THE TENTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF FARMERS' INSTITUTE WORKERS.

Afternoon Session, Thursday, November 9, 1905.

The association was called to order at 2 o'clock p. m., in the National Hotel, Washington, D. C., the vice-president of the association, E. A. Burnett, of Nebraska, in the chair.

The Secretary of Agriculture, Hon. James Wilson, was introduced and delivered an address of welcome as follows:

ADDRESS OF THE SECRETARY OF AGRICULTURE.

Ladies and Gentlemen: It is a pleasant duty and a high privilege to come over here and meet you who are engaged in this great educational work, coming from many States and Territories of the Union, and also our brethren from Canada.

The growth of agricultural education in our day has become very marked, and has exceeded everything that preceded it throughout all the ages of education among mankind. In old times, when I was a boy, I remember going to the old-fashioned farmers' club that probably is antecedent to most of the efforts that are being made to help the man who works in the field with his coat off, and there is the most wonderful difference between what was said and done in those old-fashioned farmers' meetings and what is being done now in our great educational associations along these lines. We have not very much in our libraries pertaining to the past. You take the reports of the Department of Agriculture when it originated, away back in the Patent Office, and while they are to some extent instructive, and to some extent entertaining, yet they are exceedingly different from anything we have now, and if you look over the reports of the agricultural societies of our States in early days, and of the Old World, you will be surprised again at the simplicity of the subjects discussed, and to see how very little that seemed to be the result of research is found in that old literature.

It is very different now. We are organized along a good many lines, all of which it is not necessary to enumerate, the work in which is for the benefit of grown up farmers, adult people, farmers who have not time to go to school. Through progressive agriculture to-day you do something for them that is not done as well in any other way. I find that our States and Territories are nearly all organized. There are farmers' institutes found everywhere in the land now, and the farmers' institute lecturer goes as a missionary from the fountain head of agricultural information, and discusses matters that pertain to everyday life on the farm, in the field, in the dairy, and in the feed yard, and wherever science is important in making the farm more valuable. This was not done in the old days for the reason that in the old days there was no research. That is where the difficulty was. Now we have several lines of research in most of the countries in the world. There is no royal road blocked out with regard to the education of the farmer along those lines, but different countries are going in different directions in this regard. Away back in 1862, when agricultural colleges were endowed in the United States by act of Congress, there was a new departure taken as regards the education of very nearly one-half of the people. Forty-two per cent of the people in the old United States lived by farming—of all the people now under the American flag about 50 per cent live by farming—and until late years, until within a time well remembered by all of us here, there had been no systematic effort made to educate that half of our people in economic lessons, or to prepare them for making the day's work go further, or for making the acre yield more. That is the date to which we look back as the beginning of a new era for the American farmer. Some of the States in the Union had organized before that time, but a great impetus was given then, and the measure of success we have had has depended entirely on the march of education, on the men in those several institutions in our States and Territories to do this work. We have had to be patient until our teachers became educated—educated themselves; until the colleges had time to work and produce a class of men who could give instruction along these lines, as in contradistinction to instruction along literary lines very rapid progress is being made now.

The Department of Agriculture, another educational institution, is here now in obedience to the demands of the waiting farmers of the United States. The old Grange was organized for purposes pertaining to social life, and what pertains to the best interests of the farmer all along the line, and brought a powerful influence to bear upon American farm society. Eight years ago, I remember, when I came down here to associate myself with the gentlemen in the Department of Agriculture who had charge of this work, I came with the full intention of doing all in my power to help strengthen the State organizations to make the Department of Agriculture useful to the State organizations—to make the Department of Agriculture subservient to the best interests [illegible]rch and education within the several States and Territories of the Union; but [illegible]ked at that time what was well known to others, but was comparatively new to me, [illegible]at the Department of Agriculture could not be developed and enlarged and strengthened by applying to the educational institutions of the land for men educated to do its work and carry on its researches. And so we have found it necessary to train men in the Department, and to that end between five hundred and six hundred young men, mostly graduates of colleges—preferably of agricultural colleges, when we can find them—have been brought into the Department and given facilities for instruction along post-graduate lines, and put in small parties under our trained scientists in order that they may become valuable in carrying on our work. That policy has been carried out in regard to all the bureaus of the Department. Take one of the oldest—the Weather Bureau. No institution in the land was paying any attention in those days to the education of any number of the American youth along meteorological lines. It became evident to us in the Department that we must have some beginnings made with the young people to train them along those lines if we ever expected to increase our knowledge of meteorology to the point of making it an exact science, and so we have instructed our observers, located in the neighborhood of State institutions, universities, and independent colleges to give lectures to students; and now we have twenty men in the great institutions of the country lecturing to students along those lines. So that we have hopes of having scholars in the land in future along those lines. Thus we have encouraged education along the several lines of the work we carry on in our Department. This, however, is familiar to you gentlemen, but it is illustrative of the necessity for education along agricultural lines. In many directions there is no calling upon earth that requires a man to be so well educated as that of agriculture. We have begun a new work in our day. None of the institutions of the country formerly paid any attention to the soil of the country. If there was one which did I do not know where it was. I may have heard of it, but I do not remember where it was. We have organized a bureau now to study the soils of the country, that is maintained to obtain as great a result as possible for the benefit of the people who till the soils, to learn what the soils will do best, and in what direction they can be most helpful to the tillers of the soil, and to find out what crops will grow best on the several soils; and we are doing that all over the United States. In short, wherever the farmer needs help we endeavor to train somebody to help that man, if we have not anybody trained now. That man's cry to us for help is never forgotten. If we have nobody fit to help him out to-day, then it is high time we were getting somebody prepared to help him; and so we are working along those lines in the West and the North and East and the South. If the farmer needs help, the policy of the Department is to help him, and to give the law-making power, the power that makes appropriation, no peace until he gets it.

I might say a word of our visiting brethren from Canada as an illustration of the extent to which our interests and theirs are bound up together. I was thinking about the well-being of our people along the northern tier of States sometime ago, and I found they were growing a crop of wheat once in every two years, and leaving the land fallow half the time; and the crop once in two years was getting less and less. It occurred to me, "What can we do to help those people to do better than that?" People in Europe did something of that kind a century ago, but no intelligent farmer there thinks of summer fallowing nowadays. It occurred to us that it might be wise to ascertain what people did in the Old World along the lines of agriculture where the conditions are similar to those found on our northern border, and so we sent explorers to Norway and Sweden and Finland, to places where people had lived for thousands of years, and people can not live without growing crops and keeping domestic animals. We wanted to find out what crops those people had. I confess that I was not thinking of our friends in Canada, but I think when we get those things here the Canadian people may be interested in some of them, because they are still farther north than we are. Then we sent an explorer to the other side of the world, and told him to go up along the Yang-tse-Kiang River, and go away up to the foothills of those great mountains where people have lived, that we know of, for thousands of years (because we have the history of the Chinese people for that length of time), where the peach and the chrysanthemum originated, to find out what legumes grow there and bring them to us, so that we could send them to our northern tier of States, and to bring us the vegetables and fruits and everything else, so we could help our farmers up there; because some day the people of North Dakota are coming down here to ask us what they will grow in the off years when they can not grow wheat. Of course anything we get which will be of benefit to the people under the American flag will be quite as freely extended to our brethren on the north side of the line as to our own people, because we really keep no secrets and hold nothing back from anybody. I recollect when I was called to the directorship of the Iowa station in 1891 the first thing I did was to go up into Canada and steal every idea I could lay my mind on and bring it down to the State of Iowa. So we are under some obligations to those Canadian people.

The matter that is uppermost in the minds of educators along the lines of agricultural science is with regard to the education of our young people in the common schools and in the secondary or high schools. I was delighted to meet the other day Sir William McDonald, of Canada, a gentleman who has done what I never heard of being done in any other country on earth He gave a quarter of a million dollars to introduce the elements of agriculture into the common schools of Canada. Think of that! We have people in the United States who give. They give as much as ten millions at one time for educating along this line and that line, but it never has occurred to anybody in the United States to endow education in the primary and secondary schools. The farmer has been supposed to be a fellow who had a place, and it was probably best to have him just stay in that place. It has not occurred to anybody that it was best to educate that man: and yet it is. Two things which have just come to my attention, one of them mentioned to me by one of our scientists, illustrate that. The people down in South Carolina, on their great river bottoms and seacoast lands, have been growing one of the finest rices in the world for many years, at a great profit. But lately a portion of those lands have refused to grow rice. Disease has come, and they have gone to growing weeds. Well, the fact that they grow weeds is a hint to any man who has any knowledge of research. Wherever weeds will grow we can grow something that is useful. So they asked us to see if we could not do something with regard to the cause of failure of rice on those lands that seemed to be so rich that there is no limit to it. We sent our crop experts down there, and, in cooperation with the experiment station pathologist, began making studies, and we got the cause of the trouble finally. After two years' work it was found that those rich lands had become too sour in places even for rice. Heavy liming was tried, and the experimental fields thus treated grew abundant crops. This indicates that those lands may be brought back into bearing again. A very simple thing, but it did not occur to the rice growers and they were nearly ruined. Plans have been made to make big practical farm tests of the results of these experiments. New crops of promise have also been introduced.

Now, the other thing that has just been brought to my attention is also a very simple thing. We have an apple known as the Albemarle Pippin. One of our ambassadors at the Court of St. James away back in the olden times gave Queen Victoria a barrel of those pippins, and she was so delighted that she sent for them every year after that. But the trees were attacked with what is known as the bitter rot, and the people lost the crop. They sprayed for it, but it did no good; the bitter rot took the whole crop. Finally it occurred to our pathologists that they did not begin spraying soon enough, and that they ought to begin before the leaf comes out. So they began with a large orchard early in the spring in that way, they sprayed throughout the whole summer, and they saved the entire orchard. That means much to the people who grow the Albemarle Pippin. These are simple things, but it requires men of training and observation to do this kind of work.

The attention which the Department has given to irrigation has possibly led to the adoption by the United States Government of the most magnificent system that is designed to use the surplus waters of all those great rivers in the western half of the

United States for growing crops and making homes where people can live and raise families and live in comfort and happiness. All those lands are exceedingly rich, and our Department has done a good deal toward indicating what can be done with them. One feature of our work is to grow crops where you can not put water. It is a simple thing to grow crops in that rich soil if you can get water, but it is an entirely different thing to grow crops above the ditch where you can not get water; and many, many millions of acres in the United States are in that condition. Our explorers a few years ago searched the Old World for crops that would grow in a light rainfall, say 10 inches. They went to the dry lands of Russia and the dry lands of Algeria, and they found crops that had been grown in light rainfall there for many years, for so many years that history could not tell us anything about it. They brought them out here to our dry lands. I can not go into the details of the experiments, but this year we will have probably twenty million bushels of wheat grown above the ditch, where water can not be got to it, which will be used for making bread. We are using it every day in the city of Washington, and you are eating it now, but you do not happen to know it It is as good as the bread we get from the rainy country wheat, and it is richer in protein and the muscle-forming ingredients. Wherever we find that the American farmer is needing help, we go there and see what can be done for him. There is nothing really the matter with any acre of land I ever saw, but there is a very great deal the matter with us. We do not know enough. Wherever you see an acre of land growing anything, that is your hint, and it is our business to find out what will grow that is beneficial to the owner of that land. These are the lines along which we are working. And now our institute worker goes to the agricultural experiment station and to the agricultural college, and the Department of Agriculture gets the results of this research and takes it out to the farmer, to the practical farmer, to the man who is making his living by farming, and helps him to better methods and more profitable ways of managing his crops. That is your field. It is your business to know everything that is being done by the man who experiments and observes and makes research. It is your business to become possessed of all of the results of work along every line of agriculture, and then to go out in the field and get farmers together and put practicality in their hands and in their minds new ways and facts, so that you strengthen them; and consequently you become missionaries for that purpose; you become the most powerful medium we know of. The press is doing much to help along with the dissemination of discovered truths in agriculture, it is doing a great deal in newspapers and magazines and books, and we have come to the time with our college men and our station men when agricultural men are putting on the market text-books which twenty years ago nobody could have had. And so, as I remarked a while ago, what is uppermost in the minds of educators along agricultural lines is the getting of the young fellow from the farm in the common school and secondary school headed toward the farm, instead of away from it. There are no well organized opposers nowadays of an agricultural education. What opposition may have existed has been given up. The farmers are organizing, and I am watching with intense interest the organization of farmers for the purpose of protecting themselves against those who have heretofore preyed upon them. There is no declaration of independence that is more valuable than just that. A community of farmers grow a great crop. The world needs that crop; the world must have it. In old times the law of supply and demand regulated the price. In modern times combinations of people who neither grow nor spin nor consume the crops are organized for the purpose of making all the profit possible from them. The farmers have bethought themselves that they are interested in a peculiar degree in the growing of those crops, and I have no doubt at all but that the price of crops will be arranged amicably in the future so that the men that produce them will have their remuneration. I do not want to take a demagogical position with regard to anything, but a lively illustration comes to my recollection just now. Some years ago the price of beef went up very rapidly. It was not doing so much good to the people who grew the beef, but the people who consumed the beef felt it very keenly. A newspaper man asked me if the packers were altogether to blame. I said, "Probably not; I think the middleman may have something to do with it; the retailer may have something to do with it, possibly." A man here in Washington, a retailer of beef, took me in hand and gave me a very thorough talking to, and exposed my ignorance, and told the world that all the profit that he had was 40 per cent on the beef he sold.

Now, I do not see any particular necessity for anybody having such an enormous profit between the purchaser and the consumer. If the old law of supply and demand had been let alone—it was a comfortable old law, and writers on political economy, like Adam Smith, built magnificent structures on the top of it; but it is all gone. [Laughter.] The law of supply and demand does not exist any more in regard to many things. It is a question of giving the farmer just enough encouragement to go on and grow crops, and those who neither grow the crops nor consume them want to make the money out of them. I do not imagine that the people who consume these crops get any more out of it than the people who grow the crops. The difficulty is with the fellows who want to intervene.

Gentlemen, I make you heartily welcome here to the city of Washington. This is the political center of our country; it is the scientific center of our country; it is rapidly becoming the social center of our country. It is growing rapidly. We American people have a good deal of pride in it. I might say, also, that this is becoming the great convention city.

I hope you will enjoy your visit here and take away pleasant recollections, and if there is anything we can do for you over in the Department to further your work, all you have to do is to call upon us.

F. H. Hall, of Illinois, delivered the following—

REPLY TO ADDRESS OF THE SECRETARY OF AGRICULTURE.

We appreciate, surely, the words of welcome that have come to us from the Secretary of Agriculture. We expected it. It is on the programme. He is our Secretary and we are his agents. In a sense we are members of his official family. He welcomes us to Washington, and we welcome him to this meeting. We are especially pleased that he has given us a clearer idea than perhaps some of us have had before of the work of his Department. We know now, what some of us believed before, that the source of life of the farmers' institute is not the agricultural college, and surely not the college of literature and liberal arts, and it is not the common schools; it is the Department of Agriculture and the experiment station. There never were such farmers' institutes as we have to-day until after the Hatch bill passed Congress in 1887. That was the beginning of these better things.

The old-fashioned farmers' institute in which farmers met and exchanged opinions may have had some life, but it is not to be compared with the institute of to-day in which we attempt to bring the farmer himself into touch with the experiment stations and the Department of Agriculture. President Roosevelt said, and the Secretary has said the same thing here to-day, that nearly one-half the people in this country are devoting their energies to producing things from the soil. And surely it is high time that we devote some thought to the special education of that portion of our population. President Roosevelt says, also, that the Department of Agriculture is a great educational institution. Do the people over the country know this? Do they all of them know it, or many of them know it? The Department of Agriculture is a great educational institution with a faculty made up of more than two thousand specialists, and expending millions of dollars a year to find out things for the farmers, and not one farmer in a hundred is in touch with that work. The primary work of the Department of Agriculture, as it is now organized under the Secretary of Agriculture, is discovery and investigation, and the secondary function of the Department of Agriculture is dissemination; and I have heard Professor Hamilton say that dissemination does not keep pace with the discovery. We are those who are engaged in dissemination. That is our special work. I have heard Professor Hamilton say that the scientific agricultural knowledge that we now have is, as it were, a great reservoir full to overflowing, with pipes leading thereto that are pouring in an additional mass of knowledge constantly, but the mains from which have scarcely been laid. It is our business to help lay the mains. It is our business to encourage the sentiment that will get the right of way to lay the mains. It is our business to lay also the laterals into every school and home in the country. President Creelman said once that the farmers' institute has done more to help the farmers of the United States and Canada during the last ten years than any other agency. I believe it to be true. How has it done it? Simply by bringing the farmers to some small extent into touch with the experiment stations and with the Department of Agriculture. That is the way the work is done. It is done by creating a sentiment that would teach us and educate us all along the line to do what people never thought of doing before. What has it done in my own State of Illinois? It has created a sentiment that made it possible to get a legislative appropriation of $150,000 to erect a building in which to do our work. It has created a sentiment that makes it possible to appropriate every year $25,000 for the study of our soil, $25,000 for the study of beef production, $15,000 for the study of horticulture, $15,000 for the study of dairying, and $15,000 for the study of growing corn, wheat, oats, and clover. The members of this association are people who have been connected with this for a longer time than I have, but anybody who will look at this matter will find that the farmers' institutes have made the sentiment which has made all this possible.

That is not all. We are making a sentiment that will make consolidated schools possible. We are making a sentiment that will carry elementary agricultural science into every common school in the land. We are making a sentiment that will put agricultural science into the high schools, and articulate the common schools, through the high schools, with the agricultural colleges, and also with the schools of science and the liberal arts. We are making a sentiment that is helping the new education.

Do we know what is the new education? What is this wonderful change which has come over us as to what education is for? Education is, in the minds of many leaders, no longer for the purpose of producing simply enjoyment, even though it be of the higher intellectual sort. It is no longer to bring about a kind of philosophic leisure. It is now for use. It is to help young people to do things that need to be done. If it is not for use, it is useless. And almost all over the country, from Doctor Eliot of Harvard to Doctor Jordan on the other coast, the leaders are asking for the education that will reproduce itself in the power to do something that needs to be done; not only the power but the disposition—the desire and the power to do useful things. I think that in our own university a few days ago, when President James was inaugurated, we heard the keynote of the new education. I have here a copy of a few words that he spoke, and I am going to use those words in every county of Illinois this winter. I will read them here. I say they are the keynote of the new education, the education for which the farmers' institutes stand. He says:

"In a word, the State university which most fully performs its function for the American people will stand simply, plainly, unequivocably, and uncompromisingly for training for vocation; not training for leisure, nor training for scholarship, except as training for scholarship is a necessary incidental to all proper training for vocation, or may be a vocation in itself."

This is the doctrine of the new education, and the farmers' institutes are helping forward this movement, and they stand ready to help for this reason, that nearly half of the people in this country devote themselves to producing things from the soil. And because we stand in a position to help that one-half of the people we are in a position to help forward what I call, as I think properly, the new education, education for useful activity.

And now, in conclusion, I beg to assure the honorable Secretary that we thank him for his words of welcome and his unmeasured helpfulness in our work.

Prof. E. R. Lloyd, of Mississippi, read the annual address of the president of the association, J. C. Hardy, as follows:

PRESIDENT'S ADDRESS.

Ladies and Gentlemen of the American Association of Farmers' Institute Workers: In behalf of the association I desire to express to the delegates from Louisiana our deep regrets at not being able to meet at this time in their beautiful capital city of Baton Rouge. Personally it has been a great disappointment, and in order that the anticipated pleasure may not be lost forever, I do now put in nomination Baton Rouge for our next place of meeting and hope that at the proper time a motion to this effect may be unanimously adopted.

I desire to discuss for a short while, upon this occasion, "Federal support for farmers' institute work."

It seems to me that the time has come when the real value and importance of this movement should be brought to the attention of our national lawmakers, whose beneficence and generosity have done so much for our agricultural colleges and experiment stations and through them for the agriculture of the entire nation. The executive committee of this association, realizing the necessity of a closer organization within itself, have recommended the appointment of some permanent committees to do continuous work along certain lines from year to year, and I can not too strongly urge the adoption of this recommendation, but, in my judgment, it is infinitely more important that the work as a whole should be put upon a broader and more permanent foundation by being unified, nationalized, and supported by Federal appropriation. If agricultural and industrial education is a national question and deserves the support of national appropriations, how much more so are the problems and questions with which this association is dealing? If it is of national importance that the hidden and dormant forces of nature should be discovered and brought to light, of how much more importance to the nation is it that these forces and laws thus discovered should be applied and utilized, not only for the betterment of the individual, for the upbuilding of the State, but for the strengthening and enriching of the nation?

No one can read the able reports of Secretary Wilson, our leader in agricultural thought and action, without being impressed with the importance of agriculture from a national standpoint and without realizing more than ever before what a debt of gratitude the whole country owes to the American farmer for maintaining our trade balances which are so essential to American prosperity and independence. One of the purposes of the farmers' institute is to increase the production of the country by inducing the farmers to put in practice that which has been worked out by the experiment stations and proven worthy of being incorporated in the industrial life of a people.

I have never believed in "art for art's sake" and "knowledge for the sake of mere knowledge." I believe that every art was intended to be applied either for the pleasure or the profit of the human family. It is a good thing to know the truth, provided you use the knowledge contained in the truth. The architect's conceptions contained in the plans and specifications of great and beautiful buildings, such as we have here in the capital of the nation, are valuable only after master builders have given them form and substance. The thought in the mind of Justin S. Morrill that was destined to revolutionize the educational conception and practice of the country could accomplish nothing until embodied in that memorable act of 1862 which called into being the land-grant colleges in every State and Territory of the Union. There is no one in all the land who appreciates the work of the experiment stations more than I. As president of the Mississippi Agricultural and Mechanical College, I give the director of our station and his corps of workers all of the cooperation and encouragement that lies within my power in their search after the hidden and unknown laws that God intended should be applied by the farmer of my State in working out for our Commonwealth a safe, sane, and sound system of agriculture. Then, realizing as director of farmers' institutes that the laws thus discovered and the forces thus brought into light are worthless without being applied, I send these same men, together with others with equal power and ability, to induce the people of my State to put into practice that which has been worked out by our investigators. The men who are doing all within their power to induce the farmers to apply the laws that have been discovered by the investigators are doing a work of equal importance to that of those making the investigations and a work that is even more pressing, for practice is many years behind knowledge. Who can realize what it would mean to the country if every farmer in the land could be induced to apply the knowedge that the experiment stations have worked out and published during the past fifteen years at a cost of more than twenty millions of dollars?

Mr. John Hamilton, our Farmers' Institute Specialist, who has done so much for this association and for the cause it represents, in an address before the farmers' institute workers of Pennsylvania last year, gave some figures that I am going to take the liberty to quote, for they illustrate the force of the above observation and of the value of the work we are doing. He said:

"If a sufficient force of teachers of agriculture were at work constantly in each State instructing farmers and demonstrating the value of new crops and new methods, the production of the country would speedily be greatly increased. Five dollars added to the value of each dairy cow would increase the wealth of the farmers of the United States over $90,000,000. Two dollars added to the value of each of all other cattle would increase it by over $100,000,000 more. Ten dollars to each horse would increase their income by over $213,000,000. Thirty eggs added to the annual production of a hen, whose average yearly output is now but 66, when it might be 200, would add over $64,000,000. One pound to each chicken at 10 cents a pound would amount to over $23,000,000. One-fourth increase to the present product of fruit would amount to over $19,000,000. One-third added to the present product of potatoes and grain would be more than $524,000,000. One-third added to the staple products would amount to over $306,000,000, and with like additions to other crops and animals not enumerated, would reach a total of $1,442,419,469, all added to the present product and all going into the farmers' bank account."

And he might have added, to the bank account of the nation itself.

Upon such a showing as this, surely we are justified in behalf of the isolated farmers, who stand so greatly in need of such help, as was so forcefully pointed out by Mr. Hamilton, but whose forces are too scattered and weak to be heard at the national capital. I say surely upon such a showing as this we are justified and more than justified in asking of our lawmakers, who hold the purse strings of the nation's wealth, thus so greatly augmented by the application of scientific and intelligent methods, that they place the farmers' institute work of the country or the work of application upon the same footing as they have placed agricultural education and agricultural investigation, by making a liberal appropriation for its support in every State and Territory of the nation.

The agricultural prosperity of a State or nation depends upon three great forces—agricultural education, agricultural investigation, and agricultural application, which three forces are as interdependent and as triune as the body, mind, and soul. Hon. Justin S. Morrill, who immortalized himself by being the author of the act of 1862, which made him the father of the land-grant colleges of America, certainly had in mind these three great forces, and certainly intended the agricultural and mechanical colleges to perform the three functions of education, investigation, and application. He certainly intended them to be more than institutions of pure science, for his very purpose was to differentiate them from institutions of the general science and classical type, by making them technical or institutions of applied science.

President Thompson, of the Ohio University, in discussing the mission of the land-grant colleges before the Association of Agricultural Colleges and Experiment Stations at its session here two years ago, said:

"Mr. Morrill's argument in support of the bill was chiefly from the side of agriculture. He presented statistics showing that the conditions of agriculture in many regions were growing less favorable and that the products of the soil were decreasing to such a degree as to endanger the perpetual prosperity of that great industry. The decrease in the number of animals and somewhat widespread discouragement in the older States led him to make a strong plea for such provision as would eventually prevent the exhausting of the soil and maintain the permanent prosperity of the farmers."

This was the work that was to be done by the colleges that Mr. Morrill was seeking to establish. He conceived this work to be of national importance and deserving national support, and who in all the land now doubts that he was right or denies the wisdom of his course?

It soon became evident to the thinking and observing men of the country that the one college organization could not do the work intended, and so the conception of the work expanded and gave birth to the experiment station as an adjunct to the college. The Hatch act of 1887 gave them a distinct organization and made what was thought at that time ample provision for their support. And who now doubts the wisdom of this act? No intelligent man can be found who is not proud of the work that has been accomplished by the experiment stations of America. But as excellent as has been their work, I am sure that much more would have been accomplished had there been a clearer conception of the specific functions that the experiment station was intended to perform. The Hatch act was intended to create a distinct instrumentality for the accomplishment of a distinct work. Otherwise it might have been styled "An act to still further endow the land-grant colleges." The purpose of the act was not to enable the colleges to strengthen and extend their work such as was accomplished by the second Morrill act of 1890, but was to give them an additional organization especially adapted for making investigations and experiments, a work which the college as a college is wholly unable to perform. The work of the college is one thing and the work of the experiment station is another. My position is that just as in the fullness of time it became necessary to differentiate the work of the college by evolving the experiment station as a separate organization with a separate endowment, the time has come when the work of the experiment station should be differentiated and when there should be evolved a separate organization, to be known as the farmers' institute, and supported by Federal appropriation. It is perfectly clear that when the Federal Government appropriated more than 11,000,000 acres of land for the support of the land-grant colleges, it was intended that a part of their work should be that now being done by the experiment stations. It afterwards became evident that the work could be better done by two organizations than by one; and as a result of this conviction the Hatch act was framed and passed, calling into existence an experiment station in connection with every land-grant college in the country. I believe the time has now come when the work mapped out in the Hatch act can be better done by two organizations than by one. The question of putting the farmers' institutes upon a national basis and supported by Federal appropriation does not involve a new principle, does not require an extension of power on the part of Congress, for the very work that the farmers' institute would do in an organized, consecutive, and efficient way is now being done by many experiment stations and colleges to a small extent, and only at such times as least interferes with their regular organized work. Their regular organized work is growing and expanding to such an extent as to require all of their time, money, and energy. The question then reduces itself as to how the work may be done the most efficiently and the most economically.

It is a question of organization, for as before stated the work is partially being done by the experiment stations and is being paid for by the Federal Government. That the work is important and should be continued is known to all intelligent citizens. To emphasize this point, I quote from Dean W. A. Henry, of Wisconsin, who said in his address before the Association of Agricultural Colleges and Experiment Stations at its meeting in New Orleans in 1893:

"One reason that every earnest, faithful, working experiment station has a strong hold on the agricultural people is because its workers have met the farmers at the institutes and farmers' club meetings for frequent conference and have given instruction through the agricultural papers, acting in no small degree as teachers and counselors. It is true that when a station worker is on the institute platform or addressing a farmers' club he is not investigating, and when he is writing for the agricultural press he is not doing laboratory work, but the call for help from our farmers has been so great and their appreciation so marked that it has been impossible to escape it. With earnestness on both sides and a desire to give and receive help, the most cordial and close relations now exist in a number of our States between the experiment stations and the intelligent farming people. To be frank with you, I believe that our station workers have in many cases accomplished more good for the cause of advanced agriculture through their efforts at instruction than through all they may have discovered."

Dean Henry has given us the whole problem in a nutshell. Discovery, investigation, or experimentation can accomplish nothing unless they be followed by instruction that has for its end the application of the results to the industrial life of the people. I repeat: It is a good thing to discover, but it is a better thing to make use of the discovery. It is a good thing for the legislature to make good laws, but those laws are absolutely useless unless executed.

Just as one of the most pressing needs in our political or civil life is the execution of the laws on the statute books, so in our industrial life—that is, in our agricultural life—the most pressing need at this time, it seems to me, is the execution of the successful experiments now embodied in our station bulletins. The law requires that the results of the experiment stations shall be published in bulletins and sent out to the people. Why this requirement? It is because the very purpose of these experiments is to give the people something that will help them to improve their agriculture. Are the masses of the people capable of interpreting the results as tabulated in many of the bulletins that come from our experiment stations? Is it possible to stimulate agriculture and to arouse the people to the importance of the many problems with which they have to deal by means of experiment station literature? I am not making an attack upon the literature that comes from our stations, for there is no man in this country who believes stronger in the stations, or who has more confidence in their ability to solve the problems with which they are confronted than your speaker; though I do think that they should issue more popular bulletins, and make all of the bulletins less technical. The workers of the stations should always realize that their work is primarily for the farmer and not for the general benefit of science, and when they write the results of their work they should ever keep in mind that they are writing primarily for the benefit of farmers and not for the benefit of scientists. They should be more concerned that the farmers should think well of their work and writings than about what judgment the scientists of the country might pass upon them. But even with perfect literature the results would still be far from satisfactory. As well expect political battles to be won by circulars and glaring headlines in the daily papers, or the world to be converted by tracts and religious literature, as that the battle of progressive agriculture should be won by experiment station bulletins.

Just as the living, breathing preacher, charged with the Spirit of the Holy Ghost, is necessary to bring conviction to the minds and hearts of the sinners, and just as the fiery political orator is necessary to enthuse and arouse the voters, so is the living institute worker necessary to accompany the bulletins and to meet the people face to face and to interpret to them the facts that have cost the Government millions of dollars to bring to light. I believe the work of the agricultural college, the work of the agricultural experiment station, and the work of the agricultural institute are all one, and that they can not be divided without serious injury to all. I believe each should have a separate Federal endowment with separate heads, but all under one board and one management, in order that there may be perfect unity and harmony and the best possible cooperation. I am not criticising the arrangements that exist now in the various States, for the work has been initiated in the different States under different circumstances and has been shaped by the different forces that called it into being. This has all been an educational process. It would have been exceedingly unwise to have put the burden of maintaining this work in the different States upon the colleges and experiment stations. But has not the time arrived now when the National Government should come to the relief of all and endow this work just as the college and station have been endowed? In my judgment the work is of equal importance, and in many respects more complex and pressing.

With the agricultural college standing for general agricultural education and for the training of the leaders of agricultural thought and action; with its influences permeating every nook and corner of the State, inoculating the teachers of the public schools with the spirit of industrial education; with the experiment stations manned by men especially adapted to investigating and to experimenting, and relieved of the greater amount of teaching that they are now required to do, and of all other additional work that interferes with the continuity of their efforts; and with the farmers' institutes as connecting links between them and the people, to keep them in touch with the people and the people in touch with them, and seeing that not only no force generated by either is unused by the people, but that every progressive movement of the age shall be appropriated by them as far as the forces are adapted to their needs and conditions—I say, with these three organizations working in harmony for the uplifting and the betterment of our agricultural communities, the time will speedily come when, with good public roads and beautiful rural homes; with telephones and free rural delivery, with all that they bring; with the universal use of improved agricultural machinery and labor-saving implements; with the soil restored to its virgin fertility and its greater yield of produce and wealth; with improved live stock and up-to-date plant breeding; with splendid public schools and churches in every community of the State, agriculture will take its rightful position of dignity and importance, and the country will contain the refinement, the culture, and the wealth of the land. Our city population will cease to be congested, and the ambition of every rightful-thinking man will be to live in the country, though he may have accumulated his fortune in the city. The problem of keeping the boy on the farm will be solved, and American civilization will become stronger and stronger, being based upon progressive agriculture.

Congress has recognized to a limited extent the claims of this work, and for the past several years has included in the agricultural bill an item for the salary of our Farmers' Institute Specialist. Since Congress has recognized the principle of helping this work, and having recognized the claims of the work, I feel sure that there will be no trouble whatever in showing that body how inadequate is this help. Until the work is placed upon the basis of a separate endowment, as outlined above, which I hope and trust will be at an early date, the Secretary of Agriculture should have at his disposal at least a dozen men who should give their entire time to the work in the different sections.

I therefore recommend that this association appoint a strong committee to present this matter to Secretary Wilson and to urge that he ask of Congress a sufficient appropriation to place the work upon a progressive basis.

I recommend that this association appoint a committee to suggest before this meeting adjourns the number of standing and working committees that this association should have.

I recommend that a committee be appointed to consider the advisability of asking for affiliation in the Association of Agricultural Colleges and Experiment Stations.

FEDERAL AID TO FARMERS' INSTITUTES.

F. H. STADTMUELLER, of Connecticut. Federal aid to the agricultural colleges and to the experiment stations is justified on various grounds. I can not agree with the remarks of the president of our association that the institute work is analogous to those two features or to those two classes of work. In other words, is the institute work restricted to more purely local issues? And if that is so, have those little circumscribed localities the right to bother and pester the United States Government for aid? I would be rather opposed to national aid to the institute work, with the possible exception of perhaps extending the aid along the lines of assistance in carrying out the work that has been suggested by the Farmers' Institute Specialist, Mr. Hamilton; and that is the gathering together, the grouping, of sections of the country, to get the educational men or institutions to provide a sort of normal school for the training, for the development, of institute people. I would not hesitate at this time to oppose any further national aid than might be necessary to cover that ground.

WESLEY WEBB, of Delaware. I think this recommendation for the appointment of a committee to take action to establish an affiliation between this organization and that of the Association of American Agricultural Colleges and Experiment Stations is a very good one, and I hope that action will be taken tending in the future to establish such relations.

G. A. Putnam, of Ontario. We have of course the same question before us as you have, that of more money; and it matters little whether it shall be the State government or the Federal Government which supplies that money.

During the past years at these conventions of institute workers very complimentary things have been said regarding the work which we are doing in Ontario, both in connection with the farmers' institutes and the women's institutes; and back of all that one of the great forces has been "money," or at least all the other forces we have would have amounted to very little if we had not had the money. So that in speaking of this question I would say to you, "get more money, by some means."

I wish to express my approval of the plan of central schools for institute lecturers, as outlined by our specialist, Mr. Hamilton.

We have one difficulty in our institute work in Ontario, and that is that in most of our audiences we have two classes to cater to, namely, the men who have attended institutes for several years and the men who are probably attending their first institute meeting. Those men who have been there several years, and followed the work, demand instruction along scientific lines. The questions that they ask indicate that they have been reading the reports and have been studying, and they do not want mere facts thrown at them; they want to inquire into the latest scientific investigation. But if we cater wholly to those men, then there are a large number of men who do not know even the rudiments of agriculture, who will not be benefited. So that it appears to me that we may have to do away with the one-day meetings and introduce more two-day meetings; and in that way we may be able to overcome the difficulty.

W. R. Dodson, of Louisiana. There are a great many admirable things in the president's address, but there is one thing that ought not to be passed without some expression of protest from those who differ. President Hardy says that the scientific investigator should think more of making the results of his investigation of value to the farmer, and pay less attention to what scientific men should say about his results. I believe he is wrong there. I think the first purpose should be for a man to find out that he is absolutely on firm ground, and if any scientific man can tear down anything he has done or said, then his work is incomplete and it is not going to be of great value to the farmer until he has discovered the truth. In scientific work the same thing holds true that holds true with regard to a witness on the witness stand. We are told that if a man sticks rigidly to the truth, it is impossible for him to contradict himself; and in scientific investigation, when a man has got on the solid rock of truth, he is going to stay right there and nothing can tear him down; and his first care and first concern, I think, should be that no scientific man can upset him. And then the second object should be to make that truth applicable to the farmers' needs.

It should be the experiment station worker's first purpose to do research work. It is seldom that the best investigator is the most efficient man to disseminate the knowledge he develops. The man that can best disseminate knowledge is seldom the best man to discover knowledge, and when we too strongly emphasize the teaching or institute phase of the station employee's work, we weaken his power of discovery.

A. C. True, of the Office of Experiment Stations. The address of the president of this association has brought to my mind certain things which have been very strongly impressed upon me of late. I was present the other day at the ceremonies in connection with the installation of President James at the University of Illinois. At that time, as many of you know, the degree of doctor of agriculture was conferred upon the first Secretary of Agriculture, Mr. Colman, of Missouri, and in connection with that occasion Mr. Colman made an address regarding the work which he did in the Department of Agriculture. It was brought out in that way that the work of the Office of Experiment Stations began just about the same time that we had the first

Secretary of Agriculture, and since that day there has been almost the entire development of the system of agricultural experiment stations, about which so much has been said here this afternoon. Now, it happens that I have had some little part in that work since that day, having received my appointment in the Department of Agriculture from Mr. Colman, and so I have been able to see the different stages of development through which the movement for agricultural education and research in this country has passed, and I have had, in my official capacity, to stand rather strongly for the idea of differentiation of functions. This was necessary because in the earlier days there was so much confusion of mind, even among those who dealt closely with these matters, that there was great danger that the funds for agricultural instruction and the funds for agricultural research would be so thoroughly mixed that the true purposes of neither would be really subserved; and so it has fallen to my lot to stand as firmly as I could for the idea that the experiment station must be essentially and primarily an instrument of research, and that the agricultural college should, on the other hand, stand for agricultural education of a high type.

I think it is clear to those who have looked into this matter that such a policy has borne good fruit, because through the efforts which were made by the friends of these institutions as they came to understand the situation, the agricultural experiment stations have so far been held to the work of research that a very large body of new truth on agricultural subjects has been collected by these stations, and the body of truth thus gathered together has formed the basis, and the only sound basis, for the system of agricultural instruction in the agricultural colleges; and thus they have been able to put their courses, which were intended to be of college grade, on a firm and attractive basis, with the result that we have an increasing body of students in those colleges who are being prepared to be the leaders in agricultural progress. And now that that has been done and the public mind is well informed, relatively, on those matters, I am sure that we have reached another stage in the development of this work. That is the one to which President Hardy in his address has called special attention, and I have been particularly impressed with the fact that the time is ripe for a decided movement along the line of the farmers' institute, and the more elementary agricultural education, as I have gone up and down the country during the past year. For in many of the States there has arisen and is rapidly broadening an intelligent desire for the enlargement of the agencies for agricultural education, outside of the agricultural college; and the agricultural college men themselves have come to see that it is not enough that we have the agricultural colleges and experiment stations teaching a selected body of youth and sending out a large amount of printed material by way of information for the people, but that we must supplement these agencies by others, which will go directly to the farmer to explain the results of agricultural research to him by word of mouth, and which will go into our public schools to there prepare the mass of our rural youth to understand, as they come into active life, what the experiment stations and colleges and the Department of Agriculture are doing for the advance of agriculture.

And so I think we have reached the time when the friends of agricultural progress in this country can do no better thing than to seriously consider what are the best means for the establishment on a more permanent and progressive basis of this great system of farmers' institutes which you represent, the extension work which the colleges are beginning to do in various lines, and all those matters which relate to the introduction of agricultural subjects into the public schools.

How that shall be done, whether entirely by support within the States, or by joint effort of the States and the Federal Government, it is not my province to discuss; but I do wish to leave with you strongly the impression that from a somewhat wide acquaintance with the movement of thought along these lines, I am sure that such a body as this association here at this time can, by its discussion, deliberation, and action, do very much to forward the movement for the more permanent and solid establishment of the educational agencies which are to reach the masses of our farmers most directly, and I commend to you therefore the earnest consideration of this subject.

Wesley Webb. I recognize the importance of that work, and also the fact that some of the States, as States, are making but slight provision for it; and I recognize the further fact, which is a very important thing, that the results of the experiment station work should be put before the farmers that they may put them into practice. So it seems to me that we come to the logical conclusion that the United States Government should, through the Department of Agriculture, handle this work in the several States. Personally, I am very heartily in favor of this suggestion of the president.

After the above discussion, the recommendations contained in the president's address regarding Federal aid were referred to the executive committee, with instructions to report the same back for action during this meeting.

There being no further discussion, the meeting adjourned until 8 p. m.

Evening Session, Thursday, November 9, 1905.

The convention was called to order at 8 o'clock p. m., the vice-president, E. A. Burnett, in the chair.

The following five-minute reports of the various States, Territories, and Provinces were submitted:

FIVE-MINUTE REPORTS FROM STATES, TERRITORIES, AND PROVINCES.

ALABAMA.

By C. A. Cary, *Auburn.*

During the year June 1, 1904, to June 1, 1905, the total amount expended was $600; number of one-day institutes, 24; number of sessions, 50; total attendance, 3,820; average attendance, 151; total enrollment at the round-up institute, 245. The amount appropriated for 1905-6 is $600.

There is a greater demand for institutes than can be supplied with the fund in the hands of the director.

ARKANSAS.

By W. G. Vincenheller, *Fayetteville.*

During the year our station has held four institute meetings, and has cooperated in twenty-six. These meetings were held as the result of urgent requests from the farmers themselves. The total number of speakers employed was five, and the amount of money expended on this work was $400. The principal new lines of work taken up were dairying and animal husbandry.

BRITISH COLUMBIA.

By J. R. Anderson, *Victoria.*

Two-hundred and twenty-five meetings were held in the Province of British Columbia during the past year, and $5,000 was spent on institute work. The general plan of the campaign was the holding of the regular meetings in the spring and autumn, to which experts were sent, and the encouragement of carrying on supplementary meetings by local men. The new lines of work which were brought about by material evolution were practical field work in the cultivation of the soil, management of orchards, judging of animals, animal surgery, roadmaking, and all such matters.

CALIFORNIA.

By E. J. Wickson, *Berkeley.*

The number of institute meetings held in California during the past year was 110. At these meetings we employed 25 speakers, and the work for the year was carried on at a cost of $8,934. Our work has been pretty much the same as in previous years, our chief aim being to reach each locality at its time of greatest leisure. This year we have particularly tried to call the attention of those in attendance at our meetings to the advantages to be derived from reading and from correspondence courses.

CONNECTICUT.

By J. G. Schwink, Jr., *Meriden.*

[For the Dairymen's Association.]

I beg to submit the following report for the year ending November 1, 1905, on behalf of the Connecticut Dairymen's Association, an organization created to advance the dairy and related interests of the State.

We have held during the year 21 meetings, as follows: Annual meeting of five sessions; 13 institutes, 9 of which were in two sessions and 4 of one session; 7 field meetings, with mornings devoted to inspection of crops and herds and afternoons to lecture in same.

The amount of money spent for institute work was $800. We have employed 74 speakers.

Our general plan of campaign is to cooperate with members of the association who are also members of granges, farmers' clubs, etc. The local grange or club furnishes the hall and refreshments for institute force and the association the programme and speakers. Much good has resulted from these meetings and a vast improvement has taken place throughout the State in the methods and systems of caring for our flocks and herds.

New lines of work to be inaugurated are the pushing out into sections where there are no granges or farmers' clubs and further develop the dairy interests of the State.

The average attendance at each meeting was 150; total attendance, 3,300.

By H. C. C. Miles, *Milford.*

[For the Pomological Society.]

For the year ending November 1, 1905, there were held 9 institutes, 1 State fruit growers' meeting, and 2 summer field days. The total average attendance at all these meetings was 2,275 persons.

The total cost of the institutes was $185 and of the other meetings $365. In addition the distribution of reports and other printed matter will bring the total cost of our work up to nearly $1,000. Fifteen speakers are on our institute force.

In our State there is no concerted plan of conducting institute work. The Pomological Society, the Dairymen's Association, and the Board of Agriculture each hold institutes and carry on the work as one feature of their work; therefore the combined reports of these organizations show actually what Connecticut has done in the line of institute work.

So far the institutes have been held upon the request of local granges and farmers' clubs, and the local arrangements are made by these granges and clubs, the advertising, selection of speakers, and conduct of the institute being carried out by the State organization. The only expense asked of the local people is the expense of the hall, all other expenses being met by the State society. Interest in institute work is on the increase in our State, and the demand for institutes is larger each year than we can supply with the funds at command.

For the coming year the legislature has given an extra $500 to the Pomological Society for the purpose of carrying on institute work, and with the work now well planned in advance, we anticipate more and better work will be accomplished in the line of carrying the benefits of the institute to the farmers and farmers' families in our State.

DELAWARE.

By Wesley Webb, *Dover.*

The farmers' institute movement in Delaware is gaining steadily in influence and popularity. Improved methods in farming and a more enlightened sentiment upon public questions are among the results of this movement. During the year 25 meetings were held at a cost of $700. Fifteen speakers were employed. The total attendance was approximately 6,000. Several meetings were held in each of the three counties, so that the institute was brought within reach of nearly every farmer in the State, yet, probably not more than one-fourth of them attended any of the meetings. Certain conditions made it advisable to hold meetings of one day each, although our experience shows that meetings of two days each bring out a larger attendance and develop a more intense interest. The topics discussed were chiefly those relating to the various lines of farming, one session being usually devoted to educational matters, and a few meetings were devoted to such special subjects as good roads and civic righteousness. An agricultural conference is held once in two years for the discussion of the broadest public policies.

GEORGIA.

By Harvie Jordan, *Atlanta.*

At the end of the fiscal year of 1905 a total of 50 institutes had been held in Georgia, and $3,500 was spent in carrying on the work. Twenty lecturers were employed, and more than 25,000 farmers reached in the aggregate attendance on the various institutes held. The sessions each covered a period of two days, one-half of each day being devoted to a women's session in which lady lecturers are employed to deliver talks on domestic economy, and on building up the country home and promoting social features in rural life. These sessions are largely attended by farmers' wives and daughters. We had an average attendance of about 500 people at each institute. Every phase of farm work was covered by competent lecturers; the question box was well patronized and everything done to advance and promote the cause of agriculture.

IDAHO.

By H. T. French, *Moscow.*

The number of institutes held in the State of Idaho last year was twenty. This number varies from year to year. We are given $2,000 every two years for institute work. Last year we held only 20 meetings. This year we will hold 30 meetings in the State.

The amount of money we have would not be ample to carry on this number of institutes were it not for the fact that the railroads give free transportation to institute workers. This is a very important aid, because many times our workers have to travel from 500 to 1,000 miles to the institutes. In one instance we have to travel 1,050 miles before we reach the farmers' institute localities. Including the travel from place to place after reaching that section of the State, and also the return trip, we have traveled 2,500 or 3,000 miles before we get back home, after holding a series of meetings in the extreme southeastern part of the State.

The number of speakers employed is from four to six. The general plan of campaign does not follow the plan in many States; that is, we have no law governing the work of the institutes in our State. We are simply given an appropriation, which is put under the direction of the board of regents. They place that in the hands of the director of the institutes, who is also at the experiment station; and it has been my privilege to take charge of it for the last seven years, and I simply use the money to the best advantage, and approve the bills, and let the results speak for themselves.

We have no county organizations, because it is absolutely impossible in the State of Idaho, where the counties are widely separated by high mountain chains or impassable mountains. We can not bring the counties together, and we have simply to go to the various sections and hold meetings, and everywhere we go we leave a local organization known as the farmers' institute, the object of which will be to perpetuate the meetings from year to year. These local organizations have grown into farmers' clubs and farmers' organizations of different kinds.

The lines of work during the past year have been numerous. We have introduced domestic economy. We have taken an instructor to various places in our State, and that plan is taking very well indeed. That is the only new line of work we have taken up in the past year.

ILLINOIS.

By B. F. WYMAN, *Sycamore*.

There were held in Illinois during the last institute year 101 county institute meetings of from two to four days' duration, with a total of 635 sessions. The total number reported in attendance at these institutes was 69,759, and at the State institute the attendance was estimated at 4,000 the first day, 4,500 the second day, and 5,000 the third day. The amount of money expended in the State in institute work was, approximately, $19,757.90. Thirty-three speakers were employed from the college of agriculture and the experiment station, while 89 local speakers were listed and used to a greater or less extent throughout the State. There were in the State 37 expert corn judges, who gave instruction in growing, breeding, and judging corn, and gave material assistance in many institutes.

The process of evolving a perfect farmers' institute is one that will be long in its accomplishment. Human nature is composed of so many and varied characteristics that many methods have to be tested, only to discard the greater number. Illinois during the past eighteen or twenty years has been passing through the process. Her farmers' institute is constantly adopting new methods and as persistently passing others. With our years of experience and tests we have great confidence that we are making important progress. We are putting the institute on a more substantial basis. We are unifying the work and getting in closer touch with the work in the counties, and the counties are depending more fully each year upon the State institute for speakers who can give ascertained facts upon the subjects under discussion. Experiences of successful farmers have been potent factors in the upbuilding of the Illinois institute, but the experiences differ so greatly, owing to different conditions under which they are gained, that nearly all the counties now demand the results of the more technical work that is being done by the college of agriculture and the experiment station. The demand for institute speakers from the station is so great that it is impossible to supply it, and we have to furnish the county institutes with specialists in the different branches of farm culture, in order that the most pertinent questions may be ably discussed. Illinois extends so far from north to south that it has a great variety of productions—wheat, apples, pears, peaches, small fruits, and vegetables in the southern part; corn, broom corn, and stock in the central; corn, oats, stock, and dairying in the northern, while domestic science, education, forestry, soils, and a multitude of other subjects are demanding attention throughout the State. To supply all these demands taxes severely the ability of the State institute. Such demands show us clearly that we are on the right track and inspire us with such confidence that we shall make the greatest efforts to supply all demands; that we shall soon be able to do so we have no doubt.

This year we have organized a boys' corn contest in corn judging, the successful contestants being awarded a two-weeks' course (short course) in agriculture at the college of agriculture, University of Illinois, in January next, all their expenses being paid. It is with pleasure that we report that many counties are moving in the matter and that some counties will send as many as eight or ten boys. We hold to the theory that if we can get the boys interested enough to want to go to the college of agriculture, we have accomplished much.

Another important move we are making is the combining of the school-teachers and farmers' institutes. We expect by doing this to accomplish much in interesting and instructing the school-teachers in agriculture. We are also working with a view to establishing a correspondence school of agriculture under the direction of the college of agriculture.

We hope to accomplish much through these new features, but it will take time to determine.

INDIANA.

By W. C. LATTA, *Lafayette*.

During the past year, 1904–5, 226 winter and 31 summer institutes were held. Of the winter meetings 109 were one-day and 117 two-day institutes. The summer institutes were all one-day meetings of two sessions each. In all, 897 sessions were held, and the aggregate attendance was, approximately, 80,000, reckoned according to the method of computing attendance approved by the American Association of Farmers' Institute Workers.

The State expenditure for the institute work was $10,000. It is assumed that the several localities where meetings were held added about $2,000 to the above-named sum. Of State funds $25 was apportioned to each county to help in meeting the local expenses incurred in holding the institutes scheduled by the State superintendent. The balance of the apportionment was used in paying the per diem and traveling expenses of speakers holding an annual conference and in meeting the expenses of the general office.

The number of assigned speakers was 47. It is presumed that at least as many local workers assisted in rendering the programme at the several meetings.

There is no uniform rule as to the proportion of assigned and local speakers, although the State superintendent recommends that about half the time be given to local speakers. In some places local speakers are not assigned any place on the programme, but join informally in discussing the subjects presented by assigned speakers.

Practically every county now has an organization county-wide in extent. Early in the spring this organization, through its officers, who represent the several townships, suggests to the State superintendent, upon his request, dates and places for meetings and subjects for assigned speakers for the ensuing year. With this information the State superintendent arranges the schedule of meetings and publishes the same about two months prior to the opening of the institute season in November.

The State superintendent assigns two speakers to each two-day meeting and one speaker to each one-day winter meeting. Extra speakers are sometimes assigned to discuss special subjects.

The several institutes scheduled are prepared for and conducted by the county chairmen in their respective counties.

In addition to serving as lecturers, the speakers are authorized to assist and advise the county chairmen in such other ways as may be deemed necessary for the good of the work.

An official report of each institute, giving attendance, method of advertising the meeting, and other information, is made to the State superintendent by the secretary and by each speaker.

Each autumn, about six weeks before the opening of the institute season, an annual conference is held for the purpose of preparing county chairmen and speakers for the meetings to follow.

The only strictly new line of work taken up the past year was the holding of summer institutes especially for farmers' wives and children. As before stated, 31 meetings were held in June and July. A domestic-science instructor, by request, attended all of these meetings. Over half the meetings were attended, upon request, by a practical poultryman. These meetings ranged in attendance from less than 25 to 200 or more. The summer audiences were made up largely of women, but there was a liberal sprinkling of children and a small proportion of men at most of the meetings. This work has proved popular, and will be continued if funds will permit.

KENTUCKY.

By Hubert Vreeland, *Frankfort.*

Institute work being practically an innovation in Kentucky, we have proceeded in a different manner from that employed by many of the States that have been holding institutes for many years. The farmers of the State were ignorant as to the nature of institute work, and it was realized that to attempt to hold a large number of meetings throughout the State with two or three lecturers would prove a failure until the farmers had come into sympathy with the movement. The commissioner of agriculture, who is the director of farmers' institutes in this State, decided to hold a number of large county institutes in various sections of the State, in order to arouse the interest of the farmers and acquaint them with the nature of the work. As high as seven lecturers were employed for one institute, and they were of such a nature as to attract the attention of all of the surrounding counties. The result is that such an interest has been created throughout the State that all of the counties are now clamoring for institutes. Beginning the 1st of January the forces will be divided, and an effort will be made to hold an institute in every county in the State each year.

Last year the department conducted only 24 institutes, but these were all conducted on a large scale and were usually held at the county seats. A number of small institutes were held at different precincts in the various counties. In addition to this the commissioner conducted an alfalfa and corn special over the State, and lectures were delivered at 73 points along the route. From one to three lectures were delivered at each point. More than 10,000 farmers were addressed in this way. The department of agriculture has also organized 45 farmers' clubs in the State, which clubs will make the local arrangements for institutes in the future. The institutes held last year averaged $70, but this will be considerably reduced next year. The department has spent during the past year $4,180 in the holding of farmers' institutes, organizing farmers' clubs, and conducting the alfalfa and corn special. Twenty speakers have been employed at various times.

The department has made it a rule to require the various counties to form a permanent organization before a county institute is held, as it has been found that with a good working body of farmers it is much easier to arouse the interest and hold a successful institute. When these clubs make application for an institute, they are directed to arrange the local part of the programme and to submit same to the commissioner, who adds the lecturers from a distance and returns the programme to the club completed. The clubs are also directed to send in a list of the subjects that are of paramount importance in their particular community, and the lecturers are secured accordingly. The proceedings of all institutes are published, and 10,000 copies are disseminated among the farmers.

The only new line of work carried out was the conducting of the alfalfa and corn special, which has done more to arouse the interest of the farmers and to inspire them to grow better crops than anything that has ever been accomplished along agricultural lines in Kentucky. Prof. P. G. Holden, of Iowa, was the principal lecturer on corn growing, and Joseph E. Wing, of Ohio, was the principal lecturer on alfalfa. The trip of the special consumed nine days, and the train was welcomed everywhere by the farmers. Twenty thousand booklets on alfalfa and corn growing were distributed along the route.

The department will organize the local clubs into a State farmers' institute within the next few months.

LOUISIANA.

By J. G. Lee, *Baton Rouge.*

I have the honor to submit the following report of institute work done in my State for the year ending, which, owing to the outbreak of fever, was severely handicapped and materially curtailed on account of the quarantine restrictions that occurred when our well-organized corps of institute workers had begun the regular summer work. Owing to the prevailing conditions, these corps were called in, and the continuation of the quarantine restrictions prevented any resumption of the work. Therefore we can only present a partial report and tell of what might have been done. In the beginning of the year, during the months of January, February, and March, we placed a competent corps of expert lecturers in the field who conducted a series of fruit and truck institutes, twenty-two in number, which resulted in increasing the fruit and truck industry and greater diversification of crops. At these institutes our lecturers explained the methods of planting and cultivating fruit and truck, grafting, fertilizing, selecting, cutting, and packing for the market; also the disposing of their products to the best advantage. I may here say that these institutes encouraged increase in the fruit and truck business, which is attracting the attention of our small farmers in several parts of the State who had formerly farmed on the one-crop plan. It is likely, with the great advantages of many parts of our State where rapid railroad transportation exists, the fruit and truck industry will become an important factor in the revenue of the State. Our institutes, notwithstanding the inclement weather which sometimes prevails in the aforesaid months, were well attended, and many intelligent and progressive farmers took part in the discussions and seemed anxious to learn more of these important subjects pertaining to their welfare.

There was also held at the beginning of the year, in cooperation with the commissioner, the annual convention of the Louisiana Agricultural Society and Stock Breeders' Association, at which stock raising and economic agricultural subjects were presented and discussed in an able manner by experienced and practical lecturers and successful laymen. Then, again, the fertilizer convention and State horticultural society was held, in which the institute lecturers took part and discussed matters pertaining to field, farm, and orchard. Lectures were given in ten summer normal schools for public school teachers.

Summer institute work, as previously mentioned, was organized into three strong corps, which were to have covered all parts of the State, but owing to the conditions as explained this work had to be abandoned. Twenty speakers and two lady lecturers in domestic science were secured for this work, and with the satisfactory results from the previous year everything augmented a much more successful institute work. The importance of more and better fairs was also taken up at the time of the fruit and truck lectures, and resulted in the organization of a number of additional fair associations for the purpose of holding more and better fairs, but only three were held, owing to the prevailing quarantine restrictions. There is an awakening interest and growing demand for fairs, which the department is fostering and encouraging with the desire to have parish and district fairs throughout the State, and eventually a State fair.

The legislature appropriates $2,000 per annum for institute work, but this amount is totally inadequate, and but for the cooperation of the Louisiana State University and Agricultural and Mechanical College and the experiment stations (which supply us with the greater part of our lecturing force), the joint assistance of the railroads, and the farmers' organizations the results would be very unsatisfactory. As it is we have been able to keep pace with the constant and growing demand for institutes, and have every reason to believe that much good is derived by the farmers from the work.

MARYLAND.

By W. L. Amoss, *Benson.*

Not having reported at our last meeting in an orderly manner I will endeavor to cover the two seasons with this report.

There has been no lagging of interest on the part of patrons in our work; on the contrary it is a pleasure to report a healthy growth and evident appreciation of benefits derived by attending the institutes. By request, from year to year, the names of the working and progressive farmers of the State are being added to the mailing lists. We believe in growth in numbers of our audience. There is a limit beyond which there will be no increase, but in value to him seeking knowledge the work has no bounds. It has been and it is our constant effort to establish a feeling of confidence between the worker in the laboratory and the worker in the field, to their mutual benefit. No time nor expense has been spared to study new theories and new facts before permitting them to be disseminated among our husbandmen.

Preparatory to proclaiming that the efforts of the National and State department are working a revolution in crop production, a delegation composed of selected men from counties on the Eastern Shore and southern Maryland were invited to visit farms in Pennsylvania and New Jersey, where probably the best demonstration could be seen of progressive agriculture and dairying in particular. These representatives read reports at the institutes in their respective counties during the season following, while during the season of 1904–5 these advanced farmers who were visited came to our State to tell how by ceaseless energy and constant study of bulletins issued by experiment stations they had succeeded. This method of preparing local men to do institute work has been conducted with the best results. It sets aside prejudice, for seeing is believing. It inspires confidence, for it leaves no doubt in the mind of anyone that the department is in earnest and will not promulgate what has not been tried.

The new and important task assigned the director to collect and install an agricultural exhibit for the Maryland commissioners to the Louisiana Purchase Exposition at St. Louis kept him actively engaged until December 15, 1904, when the work of organizing the institute season of 1904–5 was taken up and prosecuted in accord with the bill creating the department, with few if any variations from the past. We are required to give one institute in each county. Following the institute season, or the middle of March, some novel institute work was taken up at the suggestion of Director Patterson, of our experiment station, supported by our governor and an interested citizen. Trains of cars were placed at our disposal on the Maryland and Pennsylvania and Western Maryland roads for the purpose of taking to the farmers information on selecting and testing seed corn, after the manner previously advised at the special corn institutes attended by Prof. A. D. Shamel, season of 1903. This work was a pronounced success, and suggests a better method of meeting farmers for some branches of work than any tried before.

It is a pleasure to report that domestic-science work, brought to the attention of patrons and school superintendents by this department, through the energy of Miss Emma S. Jacobs, superintendent of cooking schools of the District of Columbia, has been adopted by the school board of Baltimore County. A teacher has been employed and twelve schools are being instructed, one among the colored people.

During the season of 1897–98 this department endeavored to introduce nature study in the public schools, through the work of Mr. George P. Powell, Prof. S. B. Heiges, and others. In connection with this work it has turned its attention to the teaching of agriculture in the public schools. At the request of Superintendent Simpson, of Carroll County, Prof. Charles T. Goodrich, author of First Book on Farming, has been engaged by our department to visit such schools, assigned by the county school board, within a day's walk of the county town. This work is progressing very satisfactorily and preparations are being made to start a garden adjoining each school during the spring term. Some assistance has been rendered independent institutes for the colored people by personally attending, accompanied by others. The attendance and interest have been gratifying, and we are impressed with the belief that our department should do more to help these people to become better farmers and farm laborers.

It is a pleasure to acknowledge in this report the help and support freely and gratuitously given to our department by members of the staff of both college and station. Such help has been an important factor in the success we are assured has attended our efforts to help our farmers and aid in the agricultural development of the State.

Under the class of new work I will mention that just closed, which was conducted by our department cooperating with the experiment station in its exhibition work at county fairs. An equipment was purchased, consisting of a tent with dark lining, a moving-picture camera, a stereopticon with moving-picture attachment, with which the work of exhibiting products and methods of producing them, with educational variations, was done at eight fairs with varied success. But much experience, we believe, will enable us to report something of interest next season.

The number of meetings held during the season of 1904–5 was 23, not counting special corn work nor fair work. Amount of money spent was $4,000; number of speakers employed, 20.

MASSACHUSETTS.

By J. L. Ellsworth, *Boston.*

The institute work of Massachusetts for the year 1904, which is the last for which figures are available, was remarkably successful. One hundred and fourteen meetings were held, with a total attendance of 12,426, or an average of 109 at a meeting, the largest total and average attendance since these figures have been kept. The total expense of these meetings was $1,454.64, an average of $12.76 per meeting. We are able to keep the expense down to a low figure, as the agricultural societies stand all the expense for halls, advertising, heat, lights, etc., the only charge to the State being that for the speaker and his expenses. We pay our speakers $10 per meeting and expenses, and owing to the short distances traveled in our little State, the fourth smallest in the United States in area, we are able to keep the expenses at a minimum. Probably the average expense for these meetings, where expenses were paid, is considerably in excess of that indicated by the figures given; but as there are a number of meetings, properly included as institutes, which cost the State nothing for speakers, we are enabled to keep the average down.

Our appropriation for institute work comes under the head of "Dissemination of useful information in agriculture," and amounts to $3,000 for this year. Only about half this sum can be spent in the institute work proper, as we must pay from this source the expenses of printing crop reports, bulletins, nature leaflets, extracts from the annual reports of the board, and also the expenses of our demonstration work, though this is perhaps practically in line with the institute work.

During the year now closing, the institute work has been very successful, and though I am not yet in a position to quote figures in regard to it, I feel sure that all records have been broken, both in number of meetings and total and average attendance. We are constantly endeavoring to improve the list of speakers which we employ, to cut out the dead wood, and to secure good live men on the various subjects of interest to our farmers, and we feel that we have been successful in this, as evidenced by the increased interest manifested in the meetings from year to year.

During the winter of 1905 we employed the following speakers, J. W. Sanborn, of New Hampshire; J. L. Hills, of Vermont; C. S. Phelps, of Connecticut, and John Craig, of Ithaca, N. Y., on circuits of institutes, securing an option on their services for a week each, and arranging a greater or less number of institutes for each of them in accordance with the calls received from the agricultural societies. This modification of the system in vogue in many of the other States worked very well with us, and a number of interesting and valuable meetings were held under this plan, at a less total cost than would have been the case had these gentlemen come on from their respective States for each meeting.

As the societies have to bear a large share of the expense of these meetings with us we do not feel that we can take all the arrangements out of their hands, but allow them to select their speakers from a list prepared and published by the board, also dates and places of meetings. This works very well with us, as it stimulates the local interest and makes the people feel that it is their meeting to a greater extent than would be the case if the arrangements rested entirely in the hands of a central bureau. Another factor is that Massachusetts agriculture is so varied that it is difficult to say what is the prevailing subject of interest in any community, and if left to themselves to select subjects they can usually arrive at a better solution, whereby the greatest good to the greatest number may be served, than would be possible if the matter were taken from their hands.

One feature of the institute work, or perhaps it would be better to say of the public meeting work of the board, which has been amplified during the year, is the public demonstration work. A demonstration meeting, called a summer field meeting of the board, was held at Lowell, at which we had demonstrations of spraying machines, of the preparation of Bordeaux mixture, of fruit packages, of the killing and dressing of fowls for the Boston market, of the dairy and beef types of animals (from typical specimens before lecturer and audience), and of the Babcock milk test and the latest methods of sanitary handling of milk. This meeting was attended by about 500 people and seemed to be a great success in every way. Work of this sort was also done at the New England fair at Worcester, under the direction of the board, the two demonstrations merely differing in some features and not in plan or scope. Here also the demonstrations were enthusiastically received. Another year it is the intention that this line of work shall be much amplified and improved.

Our fiscal year in Massachusetts has always ended on December 31. As a consequence our appropriations are made for the calendar year and the work in different lines goes on right up to the close of December, so that it is usually sometime later before accurate figures can be compiled. Next year there will be a change, appropriations being made to November 30, instead of December 31. Therefore if I am able to meet with you again, as I hope to do, and if not, in my report, which I shall send, it will be possible to quote figures for the current year.

MICHIGAN.

By L. R. Taft, *Agricultural College.*

The results secured in the past season's institute work have been very gratifying, both in the interest shown by the county institute officers and the farmers as a whole and by the attendance at the different institute meetings. In spite of the fact that the weather during the weeks when most of the institutes were held was so stormy that it was very difficult for either the farmers or the lecturers to reach the meetings, the attendance was several thousand greater than the previous year.

The appropriation for a number of years has been $7,500, from which everything except the local expenses of the institutes must be paid. In addition to meeting all bills for salaries and office expenses and paying the per diem and traveling expenses of the lecturers, 9,000 copies of the annual institute report, containing about 200 pages, have been printed and distributed, and a round-up institute, lasting four days, in connection with which conferences of lecturers and county institute officers were held, was carried on at an expense of about $700, for speakers, expenses of lecturers and delegates, printing, and postage.

During the year 70 county institutes, for which three or four speakers were furnished, were held. These consisted of an average of five sessions, in addition to a women's congress of one session. There were also 200 one-day institutes, with two or three sessions, for which one State lecturer was furnished.

The total attendance was 92,000, as determined by taking the sum of the attendance at all of the sessions, as determined by actual count, or about 55,000, using the method adopted by the association.

The number of institutes that we could hold is measured by the appropriation, as, although absolutely nothing has been done to secure them, applications are now on file for nearly 100 more than our funds will permit to hold.

Thirty-five paid lecturers have been used during the year, in addition to forty who have done more or less work without remuneration. In the latter list are members of the faculty of the agricultural college and the experiment station staff, and from the State university and normal schools, and various State commissions, and State department of public instruction.

After consulting with the officers of the county institute societies, who meet for the purpose of selecting the places and dates for the institutes and the topics that they wish discussed, the counties are grouped so as to reduce to a minimum the expense for traveling, and after selecting the speakers who can handle the topics desired, a skeleton programme is furnished the county secretary, who looks after the local arrangements. Each speaker is furnished with an itinerary and orders for railroad tickets at half rates.

In addition to the usual topics relating to the science and practice of agriculture, special attention has been paid to the subjects of "schools," "forestry," "good roads," and the teaching of agriculture in the public schools. The placing of the facts regarding these matters before the farmers of the State has brought about legislation permitting the centralization of schools, the creation of a forestry commission, with a State forester and forest wardens, together with a forest reserve, the teaching of the elements of agriculture in the State normal school and the county normal schools, and an amendment to the State constitution permitting the appointment of a State highway commission, and a system of State rewards for the building of roads. In the way of new work, plans have been made for the holding of a State normal farmers' institute, and a series of railroad institutes that will reach some fifteen counties. Something has also been done in the way of field and orchard institutes, with demonstration lectures in pruning and spraying.

MINNESOTA.

By O. C. Gregg, *Lynd.*

During the year we held 105 institutes, all being of one day only, with a total number of sessions of 227. The total attendance was 52,125, estimated according to the plan suggested by the American Association of Farmers' Institute Workers.

The appropriation for the year was $18,000, which amount covered the entire expense of the institutes and the cost of publishing 35,000 copies of our Annual No. 17. We employed 14 speakers during the year, some for long and some for short periods. Very few local speakers were used. Our general plan of work has been the same as heretofore, with the exception that we have held one-day meetings entirely. This has been done in order to meet, as far as possible, the many calls which we have received for institutes. We have given some special work to help the women's institutes organized two years ago. We have had two special workers visit these institutes during the year, gathering such information as will help us in furthering the work of that department.

MISSISSIPPI.

By J. C. Hardy, *Agricultural College.*

The number of meetings mapped out for the past year was 200, but on account of quarantine not more than 100 institutes were held. Twenty-four speakers were employed, and the work for the year was carried on at a cost of $3,000. The general plan of campaign was much the same as in previous years. The principal new lines of work have been to have the second day for a practical day, in which to do some practical work, such as building roads, making terraces, judging cattle, etc.

MISSOURI.

By G. B. Ellis, *Columbia.*

The principal institute months in this State are September, October, November, and December. On account of the great interest in the World's Fair which was held in St. Louis in 1904, the amount of institute work done in the State was considerably curtailed. There were held 58 one-day meetings, 44 two-day meetings, and 2 three-day meetings; the total number of sessions 256, with a total attendance of 2,560, an average of 100 per session. The amount of money appropriated for the year was $5,000, but on account of the curtailment of the work, as above stated, only $3,100 of this appropriation was used. On account of a technical ruling of the State auditor the balance of the fund reverted to the State. It had been expected to use this balance during the winter months, but on account of this ruling it could not be done. There were 30 speakers employed during the year. About half of them were from the agricultural college and experiment station. Three speakers were employed from other States. No material change has been made in the general plan for the work in this State. The traveling institute which was inaugurated two or three years ago has been continued with success. The plan of having the institute lecturers visit the schools in towns where meetings are held and deliver lectures has been extended, and we think by this method we are reaching hundreds of young people of the State. In a number of places where high schools are in session the classes are dismissed for one session of the institute, which is attended by the students in a body. Lectures especially prepared for the pupils are given.

MONTANA.

By F. B. Linfield, *Bozeman.*

The total number of meetings held during the year was 47, the number of sessions being 100, and our total attendance was about 7,000. The speakers employed on the trips for the year numbered 20, and the work was carried on at a cost of $4,000. This work is new to the State, having been started on a systematic plan only about four years ago. The interest, however, is increasing very materially. Our big difficulty is to get a sufficient number of experienced workers that we can depend upon to help us in this work. Our plan of arrangement is to work through local farmers' institutes or agricultural organizations where these exist, and where they do not to delegate some person as special representative of the board to look after the advertising locally. No particularly new features have been introduced into the work during the past year, except that the number and places of meeting are increasing considerably. During the earlier part of this month we planned and carried out with considerable success a normal institute course at the agricultural college, which I believe in the future development of our work promises to be of very great help.

NEBRASKA.

By E. A. Burnett, *Lincoln.*

The year ending June 30, 1905, was perhaps the most successful, from the standpoint of attendance and general interest, of any farmers' institute year yet held. The institute work in Nebraska never begins very early, the middle or latter part of November being about as early as our farmers can find leisure to attend such meetings. Most institute points prefer dates from the first of January to the middle of March. Our institutes began last year on November 18 and closed March 30 of the present year.

One hundred and fifty institutes were held. Of these 88 were one-day institutes and 56 were two-day institutes. Six institutes were held for three or more days. Four hundred and eighty sessions were held. The total attendance, according to the Government methods of calculation, was 67,241. Institutes were held in 68 counties.

Something over $6,000 was expended in this work. The first year of this biennium running below $6,000 left a larger amount for the second year. A slight deficit was also created by the scheduling of more institutes than could be held with the funds available. The university paid this deficit.

Farmers' institutes profit materially on account of their relation to the university. One thousand five hundred dollars was paid for salaries of the superintendent and assistant superintendent. Eighteen speakers belonging to the university staff attended 60 institutes, spending eighty-two days therein, receiving expenses only for this work. Twenty other State lecturers were employed, being paid a per diem and expenses. About 75 per cent of the institute work is done by these lecturers, who have no other relation to the university. This percentage is only approximate.

There were no women's institutes during the period covered by this report, but at three or four points the women took charge of certain sessions of the institute, furnishing the programme and being responsible for the same.

We endeavor to form permanent organizations at each institute point. These are not necessarily county organizations, some large counties having as many as three institutes and as many organizations. The permanent organization elects a president, a secretary and treasurer, and a local committee to look after the expenses and the programme.

Last year, at many institutes, corn shows were held in connection with the institute, the corn on exhibition being judged by the speaker on that subject.

Institutes are advertised through the State agricultural papers, by the printing of posters and by mailing postal cards from the central office to a list of farmers supplied by the local committee. Programmes are made by the assistant superintendent, and dates are published at least six weeks before holding the institute.

Among the special subjects treated last year were the selection and improvement of corn, the production of forage, tillage and rotation of crops, potato culture, the improvement of live stock and the feeding of cattle, care and management of swine, care and management of poultry, home adornment, scientific methods in the preparation of food, etc. At twelve institutes the question of improvement of earth roads was discussed, the "King" method of dragging the country roads being advocated.

Aside from the work done in the farmers' institutes, the university furnished the leading speakers for the various pure-seed special trains which traversed the State, advocating advanced methods in agriculture. The number of persons who attended the various seed-corn specials in the State was 41,886.

It is probable that the number of people reached by farmers' institutes during the present year will not equal that of the past year, although the demand for such work will undoubtedly increase. It is necessary to keep the expenses of institute work within the appropriation, and this can only be done by limiting the number to a point below those held during the past year.

NEVADA.

By P. B. Kennedy, *Reno.*

The past year, our third year, has been one of especial activity along the line of farmers' institute work in Nevada. Nine different sections of the State were visited, including Gardnerville and Mason valleys in the west, Paradise Valley in the central portion, and Star, South Fork, Lemoille, Mound, Ruby, and Clover valleys in the east. Twenty-two meetings were held, with an average attendance of about 40 persons and a total of about 800.

A departure was made from the regular method of conducting the institutes from that of previous years in that all the meetings were held in the country districts themselves, and not in the adjacent towns. The advantages gained were several. The ranchers felt more at home while discussing the various subjects, as no restraint was put upon them by the presence of lawyers and town orators. The attendance consisted largely of ranchers and their families, so that we were talking to audiences that we were interested in and who were interested in us. The spare time in the morning, when not taken up in travel, was used in going over the farms and becoming personally acquainted with the farmers' problems.

A great difference was experienced in the manner in which some audiences would receive us. In some cases we were cordially received and encouraged to come again; in other cases we received few words of thanks or encouragement.

The distance traveled to conduct these institutes was about 1,000 miles by rail and 400 miles by team and wagon. A driver and three institute workers proved to be a very convenient number to transport, as behind the two seats there was a place for the stereopticon in a trunk, which always accompanied us.

The main subjects talked about at the meetings this year were as follows: Types of beef and dairy animals, breeding horses, duty of water, plants poisonous to stock, range problems, weeds, insect pests, anthrax and blackleg, gophers and ground squirrels, alkali soils, teaching the subject of agriculture in the public schools, and the agricultural college. At nearly every institute lectures are given, with practical demonstrations by our principal of the domestic science department.

The cost of the institutes to the station has been about $150. This large amount of work could not be accomplished at so small an expense but for the assistance of the Southern Pacific Railway Company and the exceeding hospitality of the ranchers themselves, who opened their houses and gave us a hearty welcome, whether they thought we could benefit them or not.

NEW BRUNSWICK.

By T. A. Peters, *Fredericton.*

For some years up to 1901, meetings had been held for the discussion of agricultural subjects under the direct supervision of the department of agriculture. In 1901 an act was passed providing for the formation of a farmers' institute system. This act provides, among other things, that where agricultural societies now existing, or hereafter incorporated under the agricultural act of 1888 or amendments thereto, will undertake to hold meetings under regulations made by the lieutenant-governor in council, under section 3 of this act, they shall, by their districts, be considered as farmers' institutes. Fifty-nine institutes were established under this act and, in addition, 7 institutes were established in outside districts. During the year 1904, 139 meetings were held, with a total attendance of 5,324, number of addresses delivered being 309. In 1905, 150 meetings have been held, with a total attendance of over 6,000. The subjects treated of include the breeding and feeding of all kinds of stock, including poultry, cultivation of the soil, clover growing, soil moisture, demonstration in judging live stock, spraying, pruning, and culture of orchards, etc. The government appropriation for farmers' institute work is $2,500 per annum. No portion of this amount is used for superintendent's salary, as that work is done by the deputy commissioner for agriculture.

NEW JERSEY.

By Franklin Dye, *Trenton.*

At no time since the beginning of farmers' institutes in New Jersey has the interest in their purpose and work been so marked as it was during the season of 1904. This interest was manifested in the increased attendance, which was so general that it was the rule, there being but two or three exceptions to it and those for cause.

This increased attendance was not out of idle curiosity nor for social intercourse, but for the helpful, practical benefits the institute provides through its speakers. The interest in the addresses was close, and the questions asked showed a growing intelligence on the part of the questioners.

Another evidence of growing interest is, requests are coming in for more meetings. These signs of progress so encouraged those in charge of this work in New Jersey that a modest appeal was made to the legislature at its last session for an increase of the State appropriation for this object, and it is gratifying to state that, having a governor and a legislature in full accord with our work, the addition was granted.

Accordingly we are planning, in fact have already arranged, for an extension of our work, which will cover most of the time from November 20, 1905, to latter part of February, 1906.

The number of meetings held last year was 30. This does not include the annual meeting of the State board of agriculture nor that of the State horticultural society. The institutes proper covered 36 days and 102 sessions, or, including the two State meetings named, 41 days and 115 sessions.

The amount of money expended, exclusive of printing, postal cards, posters, and programmes, was $1,800, which would be $51 per day average for each institute day. The State prints the required advertising matter, all printing being put out by the State to the lowest responsible bidder; but the cost of such printing is taken from our appropriation. The printing, with the postage, would probably add to the expense of each institute about $3.

Speakers employed were three from other States during the season, three professors from our own State agricultural college, and five or six local speakers, who were farmers, on special subjects connected with their own special line of work, as the production of early tomatoes, production of melons, asparagus, peppers, sweet potatoes, etc. Besides being a dairy and fruit State, New Jersey is preeminently a market garden State, and a variety of subjects must be treated in our institute lectures, subjects adapted to the locality in which the meeting is held, or else the institute would fail in its purpose.

Our plan of work is simple. The first notice sent out contains a list of all the meetings to be held, the place, and the date. This notice goes to the newspapers and the various farmers' organizations. The next notice is the programme of the meetings, containing place of meeting, hall, list of subjects and speakers, a few paragraphs on the purpose of the institute, and a short statement of who the speakers are. These programmes are sent to the press in the neighborhood where each institute is to be held, also to the local committee, if such there be, to distribute among the farmers.

The third advertisement of a meeting is by large posters. These are sent to the local committee about eight or ten days before the date of the meeting, to be put up in various public places. We are of the opinion that plenty of judicious advertising secures a larger attendance than is likely to prevail where but little notice of the meeting has been given.

New lines of work have to do with old questions, interest in which, for local reasons, has subsided. For example, the peach industry, once so prominent in the State, but now on the wane, will be taken up in the coming institutes with a view to creating a new interest in a product which we believe needs only to be understandingly treated to be made profitable. So, also, the production of alfalfa in all our dairy sections especially will be discussed, and so presented as to encourage our dairy farmers to produce a generous supply of this valuable plant, which, in conjunction with corn, should make the dairyman growing both comparatively independent of other sources of food supply.

The study of soils will also be continued as to their variety, composition, requirements, etc., and this by a soil specialist from our State experiment station.

New lines of work are also embraced in our efforts to have the old, fundamental principles that underlie safe and profitable agricultural practice presented in a clear, common-sense, logical way, so that the average agricultural mind, occupied as it is with home cares and daily toil, can apprehend and comprehend what is stated and become so interested as to apply the teachings in practice.

Another line of teaching, quite as important as the one named, is to disabuse the mind of error. Errors in agricultural practice have grown not only out of misconceptions of natural and therefore scientific truth, but also out of and by reason of erroneous teachings, whether from the platform or the bulletin. Error must be cleared away before the truth can become established.

NEW YORK.

By F. E. Dawley, *Fayetteville.*

The winter of 1904-5 was without exception the most successful season of institute work that New York State has ever experienced. The season opened with a normal institute lasting six days, and held in two sections. The first section of three days was held at the State experiment station, Geneva, and the second section of three days at Cornell University, Ithaca. The speakers at the normal institute have now learned about what material the institute lecturers are most in need of, and have been able to so arrange their lectures that the normal institute is doing far more good than formerly. The value of these normal meetings is very clearly seen, and the quality of the work has been greatly improved since they were inaugurated.

The day following the close of the normal institute at Ithaca the workers began their regular institute season, and were in the very best condition for a strong winter's campaign. The first meeting was held on November 21 and the season closed on March 17, 261 meetings having been held. Of these, 129 were one-day institutes, 128 two-day meetings, and 4 lasted three days or more, with a total attendance of 87,439.

In addition to these a number of independent institutes were held, the total attendance at which was 31,000, giving an attendance of 118,439. This is a very great increase over the attendance of the winter before, but when taken in connection with a period of years it simply shows our normal average increase for each year. The winter of 1903-4 was the most inclement that New York State has experienced in years, and at many of the meetings the roads were impassable, so that the attendance that year was much lower than the average.

During the year we held institutes in every county in the State except Richmond and Kings. One of the most successful meetings we hold is in New York City in connection with the American Institute. We cooperate very largely with the various organizations in the State, the director of institutes, who is a director in most of the agricultural associations and societies, assisting largely in arranging the programmes for their meetings. The attendance at these meetings is figured in with our institute attendance, as they are practically our round-up meetings, but the attendance at summer picnics where we furnish lecturers, which is very much larger than the average attendance at the winter institutes, is not figured in.

Our appropriation is the same that it has been for a number of years—$20,000, but at the last session of the legislature a special appropriation was made to the education department of the State to enable it to pay the expenses of lecturers, which it furnishes to the farmers' institutes, as in the past.

Our belief in the advantages of the system of a central management, sending to each meeting from two to six speakers, who will take up the greater portion of the time, is strengthened each year, as the local people in New York State are far better pleased to have the work mapped out for them and carried out by State help than they are to make an entertainment of the meeting by the use of local help, recitations, and music. We discourage the idea of exhibits of implements and products at our meetings further than a rich and choice decoration of the halls. However, in a few instances something akin to a local fair is held, as much as $300 or $400 being distributed in prizes in certain sections. These matters, however, must be governed by local conditions to a very great extent.

Our special "boys and girls" sessions are very successful, and the number of young people in attendance, as well as the large number who are attending our State agricultural college, who attribute their first interest in agriculture to enthusiasm received at a farmers' institute, is an evidence of the efficiency of this line of work.

While we have not dropped the special subjects for discussion which have been on the programmes at each institute during the past few years, and are still talking good roads, better schools, and alfalfa, during the coming year we shall pay particular attention to a discussion of the newer treatment for milk fever, illustrated with the apparatus, the advantages of soil inoculation and alfalfa growing, and the advantages coming from spraying potatoes.

The period devoted to the question box is perhaps the distinguishing feature of New York State's institutes. The questions from each institute are sent to the central office, and an examination of them indicates the wide range of subjects discussed.

It is well known that the agriculture of New York is more varied than that of any other State, and that our people are engaged in more lines of special work than most others. Consequently it is almost impossible for us to follow the system of some other States of sending a given number of speakers out who are kept together from the beginning of the season to the close. To meet the conditions as they exist and have only live, up-to-date subjects discussed in each community, we find it necessary to vary the corps somewhat, although the conductor in each series of meetings usually remains the same.

Our special poultry institutes, special horticultural institutes, and special beekeepers' meetings are increasing in attendance and interest each year. The success of this class of work has brought us to the point of holding a special sugar-beet growers' meeting, where the advantages of various sorts of seed and methods of cultivation and fertilization will be discussed; also of having special potato and alfalfa growers' meetings. All these special meetings are increasing in attendance and interest each year, and are among the most profitable features of our work.

On the whole, New York State's institutes have never been more popular than they are at the present time, and four times as many meetings were asked for the winter 1905–6 as can be held.

NORTH CAROLINA.

By Tait Butler, *Raleigh.*

During 1905 the North Carolina State department of agriculture has held 81 farmers' institutes in 78 counties of the State, at which about 16,000 farmers were present. This is a much larger number of institutes than held during any previous year. On the whole these institutes have been fairly well attended, and in sections where institutes were held last year a marked increase in interest and attendance was usually apparent.

The amount of money expended for farmers' institutes in North Carolina during 1905 was about $2,000. This is exclusive of advertising, printing annual report of 30,000 copies, salary of acting director, and salaries of the workers in the State department of agriculture, agricultural college, and experiment station, from which sources were drawn the greater number of the regular institute lecturers.

The number of institute speakers employed was about twenty, exclusive of those supplied by the local committees. Most of the work was done by the regular workers in the State department of agriculture, but some assistance was received from the agricultural college, experiment station, and United States Department of Agriculture. There were also employed several farmers within the State, and in addition the services of two lecturers from outside the State were obtained.

During 1905 in every instance where there existed sufficient interest to secure the active cooperation of a local committee of arrangements a very successful institute was held. In fact the experience of 1905 more than ever before shows clearly the necessity for local farmers' institute organizations to cooperate with and assist the general institute director. To properly advertise and arrange satisfactory programmes for and arouse an interest in these meetings active local cooperation is with us an absolute necessity. Wherever such a committee had been previously secured the institutes this year were well attended, the interest manifested was intense, and the demand for a continuation and enlargement of the work very apparent. Recognizing the fact that without the active assistance of the farmers themselves the institute work could never be properly conducted nor reach that development which its importance demands, considerable effort has been made to secure as many county farmers' institute committees as possible. Up to this time such institute committees have been organized in 77 counties, and within the next six months it is expected to complete the organization of the whole State by securing similar committees in the remaining 20 counties.

A list of the leading farmers, numbering from 200 to 500 in each county, was obtained through the justices of the peace in each township, and to each of these farmers was sent a circular letter and a copy of the programme of the nearest institute. In addition posters advertising the institutes were sent to each post-office and country store in each county and a copy of the programme published in the local and county papers. Schedules giving location and dates of all institutes were published in the leading daily, agricultural, and other State papers.

No especially new lines of work have been introduced in the sense in which I interpret the same suggested by our secretary. However, the advancement in institute work in North Carolina has been very great during 1905, but has consisted chiefly in extending and perfecting the organization and work along the old lines pursued during the two preceding years. A much larger number of institutes have been held, more institute lecturers have been secured from among the farmers of the State, and for the first time lecturers from outside of the State have been used to a considerable extent.

NORTH DAKOTA.

By E. E. Kaufman, *Bismarck.*

Last year we held 61 institutes—1 of four days, 13 of two days, 18 of one day, and 29 in which but one session each was held, making the total number of sessions 140. Figured on the basis suggested by this association, the total attendance was 12,838, or 91.7 per session. The amount of money spent for institute work was $3,948.17, which amount covers the cost of publishing the annual, salaries of speakers, etc. The number of speakers employed regularly was four, although the number appearing at institutes during the year was twelve. No change was made in the general plan of carrying on the institute work. The conductor has entire charge of the corps while in the field and plans the programme at each institute to suit the needs and conditions in that particular locality. The only new line of work inaugurated was the operation of a special seed train for one week over the line of the Minneapolis, St. Paul and Sault Ste. Marie Railroad in the State. The railway management furnished the train, and all other expenses were met from the institute fund. Twenty-seven stops, at intervals of about 20 miles, were made in five days. At each stop of one hour and thirty minutes the farmers gathered into a large passenger coach or, as was more often the case, in a hall, and talks were given on selecting, grading, and testing seed grain, with the treatment of same with formaldehyde to prevent smut. Speakers from the experiment station who were thoroughly cognizant of the conditions prevailing in the territory covered accompanied the train, and the results obtained were highly satisfactory to the railway company and the institute management. The smallest number at any stop was 75, and at three places more than 500 were in attendance. By actual count the total number meeting this train was 5,555, or an average of over 200 for each stop. Five leaflets or circulars were handed each farmer on leaving the car or hall. These circulars gave a résumé of each talk and would serve to refresh the memory of the farmer when preparing his seed grain for the spring seeding.

North Dakota is and will continue to be for years a grain-producing State, and while not in any manner neglecting live stock, dairy husbandry, horticulture, etc., the institute management believes it is the part of wisdom to pay special attention to grain raising. The object of the special train, of course, is to cover as much territory as possible and thereby reach the largest number of farmers possible in a short space of time. The railroads are benefited by the increased amount of grain they are required to haul, provided there is any increase. All three of the leading railway companies will furnish a train to the institute management next March, and it is planned to devote a week's time to each road. It will cost the institute board nearly $1,000, but judging from past experience over 15,000 farmers will receive instruction relative to seed grain.

NOVA SCOTIA.

By B. M. Chipman, *Halifax.*

I now beg to report that instead of what is called institutes in Ontario we use our agricultural societies for the purpose of holding meetings and lectures. We have now fairly well distributed over the 18 counties of Nova Scotia 166 agricultural societies, with a membership of 8,426. These societies are organized in the principal farming districts through the province, and we think, considering the fact that our land suitable for agricultural purposes does not embrace much more than one-half of the province, the other being timber lands on a rocky soil with many barren stretches, and that but little more than one-half of our population depends on agriculture, the remainder being engaged in mining, lumbering, and fishing, that our work among the agriculturists extends perhaps as far in proportion to cultivated lands and populations as most of the other eastern provinces. We have been holding institute meetings among these societies, more or less, for the last ten years. About 190 meetings have been held during the past year, with an attendance of 8,062, and in addition to this we have two traveling dairy schools going through the principal farming districts. These dairy schools held a total of 384 meetings, with a total attendance of 15,891.

Our total meetings, both agricultural and those attending the dairy school, average 45 at each meeting, which I think is very good.

About six speakers have been employed at different times with our agricultural meetings, usually two together, and the total amount expended, including the dairy school, amounts to about $4,000. The general plan is to arrange meetings by sending out posters to the secretaries of agricultural societies. The route and date are fixed at this office and the secretaries put up the posters and arrange for the hall. I do not know that there will be much change in this line of work. The new agricultural college at Truro is now open, and these meetings will be continued largely by members of the staff and others.

OHIO.

By W. W. Miller, *Columbus.*

Just twenty-five years ago the Ohio State board of agriculture began the work of holding farmers' institutes. An appropriation of $1,000 was made from the earnings of the State fair, and 27 institutes were held during the winter of 1880–81. The results were so encouraging that the work was provided for and carried on by the board for ten years, and during that period 453 institutes were held under its auspices. The faculty of the Ohio State University and the staff of the Ohio Agricultural Experiment Station rendered valuable service to the cause during its experimental stage. In 1890 the general assembly, recognizing the value of the work, passed an act providing for the organization and support of farmers' institute societies. Since that time 3,070 two-day institutes of five sessions each have been held under the management of the board, or a total of 6,140 days and 15,350 sessions.

Last year there were 316 applications for institutes, but with the funds at the disposal of the board but 243 could be granted. The work began December 5, 1904, and closed February 25, 1905. From 18 to 27 two-day institutes were held each week, making a total of 486 days and 1,215 sessions; all of them held five sessions and many of them six. The total average attendance was 80,508, or an average attendance at each institute, including all sessions, of 331. In addition to these regular institutes a large number of independent meetings were held, 38 of which forwarded reports to the department of agriculture showing a total average attendance of 12,085.

The department of agriculture receives from the counties of the State $8,375 annually for the payment of per diem and expenses of speakers, and the institutes receive an equal amount for local expenses.

The importance of local organization in this work has always been emphasized by the Ohio State board of agriculture, and the responsibility of making up programme, advertising, etc., has been placed upon each society, it being required that local talent occupy at least a part of the time of each session. In this way a personal interest in the success of the work is secured. I send to the officers of the institutes, at the earliest possible date, copies of the Institute Bulletin, which contains names of speakers and their topics, institutes to be held, with dates and speakers assigned. On receipt of this information the officers of local societies are expected to make all the necessary arrangements for holding the institutes, and as a rule they are very successful. All of the eighty-eight counties in the State have local institute organizations, and from one to four institutes are held in each county, with an average of nearly three to each.

The speakers employed by the board are all practical farmers. Some of them are graduates of the agricultural college, Ohio State University, and some have taken special training at the Ohio Agricultural Experiment Station. The professors of the agricultural college and the staff of the agricultural experiment station do no regular work now on the institute force, but they do supplement the work of the State lecturers whenever their engagements will permit.

What is generally termed a round-up we call "the State farmers' institute." The first one was held in Columbus, January 11, 1887, and a two-day State institute has been held in the statehouse every year since. It is largely attended by institute workers, farmers, stock breeders, horticulturists, etc. An effort is always made to secure specialists on the various subjects considered.

The farmers' institute has come to Ohio to stay. That the agriculturists of the State have learned its value as an educator is shown not only by large attendance, but also by active participation in the work and an earnest desire to have the number of institutes increased each year.

ONTARIO.

By G. A. Putnam, *Toronto.*

The following is a brief statement of the statistics relating to farmers' and women's institutes in the Province of Ontario during the year ending May 31, 1905:

Farmers' institutes: Number of meetings held, 845; membership, 22,500; attendance, 102,000. Amount of money spent (1904): Departmental funds, $13,700; funds collected and controlled by local institutes, $12,500. Number of speakers employed, 66.

Women's institutes: Number of meetings held, 1,406; membership, 6,968. Amount of money spent (1904): Departmental funds, $3,500; funds collected and controlled by local institutes, $1,200. Number of speakers, 21.

I might be pardoned if in giving the report which is asked for on the programme I transgress somewhat by making a brief statement regarding the women's institute work as we now find it in the Province of Ontario. During the winter season, when our regular farmers' institute meetings are being held, it is the custom to send a lady delegate to those points from which a special request has been received. At these meetings it is usual for the ladies to hold a separate afternoon session and to join with the farmers' institute for the evening session. The women's institutes have grown beyond our expectations during the past twelve months. Organization has been effected in eleven different districts, and we now have 70 more organizations than at this time one year ago. The membership for the year ending June, 1905, was 30 per cent in advance of the previous year, and we now have a total membership in the 69 ridings of 8,500. We reserve most of our efforts in order to make a decided success of the series of institute meetings held during the last week of May and throughout June, extending in some districts to the end of the first week in July. During the past summer we sent out 21 lady delegates and visited 327 points, at which meetings were held. The subjects dealt with at these meetings are varied, and all lines of work which have for their object the betterment of home conditions and the uplifting of life on the farm form the basis of addresses, papers, and discussions.

We have during the past year done much to enable the home makers to meet their responsibilities from day to day; have done much to direct those responsible for the menu to supply a proper dietary for the younger and older members of the family—how best to provide the most suitable foods at a minimum of cost and labor for the building and maintenance of bodily strength. The husbands and fathers have been taught to properly appreciate the necessity for sanitary conditions about the home, that the health of the family may be insured; the benefits of fresh air and sunlight have been given prominence at all times; the advisability of the average farmer using a greater proportion of vegetable and fruit diet to replace the undue proportion of meat. The boys and girls on the farm have not been forgotten; we have endeavored to plan certain lines of work which they can undertake in connection with the institute, and have also instructed the parents as to the line or lines of reading which would be of most interest and benefit to them. In fact, anything which tends to the betterment of home conditions and the upbuilding of a strong, vigorous, and noble manhood and womanhood have been considered as legitimate field for the work of women's institutes.

The general plan of work in connection with farmers' institutes has been on much the same line from year to year, and this has been explained before this association fully upon more than one occasion. We have, however, introduced special features during the past twelve months which are likely to prove of much value to the farmers, and will also tend to popularize the work of the institutes.

Fruit institute meetings in the interest of fruit growers have been held in those sections where fruit growing is the main source of revenue to the agriculturist.

Special seed growers' meetings were held in the open field at the season when alsike, red clover, and timothy were at that stage of growth when the lecturers could illustrate their lesson by the growing crop. In this way we are endeavoring to establish system and uniformity among farmers who are making a specialty of one or more of these lines.

Judging classes have also been a feature in connection with special meetings during the past summer, and we are planning to make them prominent during the coming campaign. The aim of the department is to more and more use demonstration classes and illustrative material in supplementing the addresses of the lecturers.

PENNSYLVANIA.

By A. L. Martin, *Harrisburg.*

We feel safe in stating that our institutes had a larger attendance last year than in any previous year, a total of 150,932. Topics discussed embraced a wide range. This of necessity must be true in a State containing such a great variety of soils, climatic conditions, and home markets. The farmers, as a result of instructions received at these institutes, are rapidly adopting the most approved methods in every department of farm operations, the results of which are noticeable in the raising of more pure-breed animals, larger crops of grain, fruits, and vegetables, and of superior quality.

The number of days of institute held this season was 327. Added to this we had three days of normal institute, making a total of 330. These normal meetings have become a fixture in the Pennsylvania farmers' institute work. Their object and aim is to better equip the institute lecturer for his work. Instructors for these meetings are engaged with reference to their ability to speak with authority on questions relating to soil, animal industry, horticulture, dairying, etc., thus bringing to the farmers' institute lecturers accurate knowledge for development of the problems and lessons which they are expected to bring before the farmers of the State. Amount of money expended at farmers' institutes the last year was $17,500. The number of speakers employed was 63. In the localities where institutes were held many local speakers joined in the work with the State force. The State force of instructors is divided into five sections, each section going into a certain part of the State on a continuous line of travel from county to county until the schedule for the season is completed. This arrangement gives economy in travel and also convenience to the different localities where institutes are held, as they know in advance who the speakers are and on what days their institutes will be held.

We are undertaking, in addition to this valuable oral instruction, to introduce schools in the actual practice of dairying; that is, in a locality where butter is made in the creameries an expert butter maker is engaged to take charge of the ripening of the cream, churning of same, and working of butter, giving lessons to the creamery patrons, who form the school, along every phase of the work.

A meeting of this character is now billed to be held at Troy, Bradford County, on the 21st to the 23d of November. Professor Van Norman, late of Purdue University, Lafayette, Ind., now dairy instructor at State College, Pennsylvania, will have charge of this dairy school and class work.

Our experience teaches us that, as the agricultural chemist and botanist develop year after year many lessons in agriculture, the importance of the institute instructor, as well as the place he occupies as lecturer, will not have abated, but added to this oral instruction will be object lessons in butter making, plant growth and life, soil and soil moisture, spraying for fungi and insect enemies; in fact, the field is just opened up for this important line of work, which will multiply many fold the importance of farmers' institutes and their relation to the advancement of agriculture.

PRINCE EDWARD ISLAND.

By J. C. Readey, *Charlottetown.*

The general object of the campaign has been to incite a greater and more mutual interest in the vital agricultural problems of this Province. The plan has been to bring the various local institutes into closer touch with each other and thus stimulate a greater interest among the members in carrying out the details of the work. This was brought about by semiannual conventions, to which delegates from the local institutes were sent. The programme for these conventions was prepared by the local department of agriculture and submitted to the farmers' institute staff, who act as an advisory board.

Following this, the summer series of educational meetings were held. Sixty meetings were held in June and July, five speakers taking part. The delegation in every case consisted of one Dominion government official and one local man, the latter being a member of the Provincial Institute staff.

The new work consisted in the organization of an institute staff, the institution of classes in agronomy and seed work, the arrangement of excursions to experiment stations, and the holding of judging competitions and short courses in live stock judging.

Two thousand dollars was spent in the work and 1,692 members were enrolled.

QUEBEC.

By G. A. Gigault, *Quebec.*

The number of farmers' clubs in the Province, 575; number of members of clubs, 51,188; subscriptions of members, $66,082.23; government grant, $23,514; number of lecturers employed during 1904, 15; amount spent by the government for lectures, $8,246.

A farmers' club can be organized in every parish or township of the Province. To be a member of a club one must pay $1. The minimum of the government grant is $25 and the maximum $50. It is calculated according to the number of members. Many clubs own registered live stock. The law and by-laws of the council of agriculture allow them to hold competitions for standing crops, the best managed farms, as well as for milch cows yielding the greatest quantity of milk. Every member of a farmers' club receives gratuitously the Journal of Agriculture and Horticulture, published in both languages by the department of agriculture. In order to be entitled to a grant, a club must have at least one lecture a year.

Two experts, one on fruit culture and the other on bee keeping, are among the speakers employed by the department. Besides the lectures given by those speakers, some are also given in the Province: (1) By the professors of the St. Hyacinthe Dairy School and speakers employed by the Dairymen's Association and the Pomological Society, at meetings held by them in the Province; (2) by speakers employed by the federal government; (3) by government and syndicates' inspectors who visit the cheese and butter factories, and (4) by priests, members of the Agricultural Missionaries' Association, founded by the Roman Catholic bishops.

Lectures are almost always given in the rural centers in the evenings. In the last report of the department of agriculture of Ireland we read the following remark: "Lectures should be arranged to be given in schoolrooms or other suitable public rooms in the evenings, and should be held in rural centers. Towns and the larger villages should be avoided, as experience has shown that the greatest success attends those lectures which are given in the rural parts of a county." We believe that regulation to be excellent and follow it as much as possible. Our reports are not yet complete, but we can safely say that the number of meetings held in the Province during the year 1904–5 exceeds 900.

Since those farmers' clubs have been organized the agricultural production has greatly increased. The last census establishes that during the decade previous thereto the production of cheese and butter has increased in this Province by 341 per cent. Some exporters contend that to-day Quebec produces more dairy products than any other Province of this Dominion. That result is largely due to the dissemination of agricultural knowledge by the lecturers and the Journal of Agriculture.

SOUTH CAROLINA.

By J. N. Harper, *Clemson College.*

Last year 22 institutes were held in the northern half of the State. These institutes were conducted by 7 lecturers. This winter 32 meetings are being held in the southern half of the State. At these meetings 12 speakers have already been arranged for, and as these meetings will not close until some time in January, it is probable that other speakers will be secured. This makes a total of 54 institutes between July 19, 1905, and the middle of January, 1906.

I have no means of ascertaining the amount of money spent. It was, however, confined to the actual expenses of the lecturers, who were college or station officers, receiving no extra compensation. There was a slight additional expense for advertising and correspondence with the local managers in arranging for the institutes.

The general plan of the campaign is to have those desiring an institute apply to the director of institutes requesting that one be held. When these applications are in, the dates of the instiutes are so arranged as to enable the lecturers to go from place to place with the greatest economy of time.

Under new lines of work inaugurated and carried out there is one item of special interest that I can recall. The Southern Railway has loaned the college and station for institute work a day coach, which is hauled free of cost to the college and wherever we wish it to go in the State. This coach has been fitted up by the college so as to contain a commissary department, where meals are prepared and served the lecturers; sleeping accommodations also have been installed. The rest of the car space is taken up with agricultural, horticultural, animal husbandry, biological, geological, mechanical, and textile exhibits. In addition to this, arrangements have been perfected for stereopticon views of the college and covering scientific subjects, experimental work, and other things of interest to the farmer and the public at large. This new feature of the institute work is attracting considerable attention, and the car, which has been in the field a little over a week, is being inspected by thousands of people.

SOUTH DAKOTA.

By M. F. Greeley, *Gary*.

Up to this year there has been no regular appropriation for this kind of work and consequently there have been no institutes other than a few local ones carried on by the people of the neighborhood. Some of these, however, have been very interesting and of much value to the localities in which they were held. At the last session of the South Dakota legislature an appropriation of $5,000 a year for the next two years was made. An institute board of three members was also created, consisting of the regent's committee of two in charge of the agricultural college, and the president of that institution, whose duty it shall be to have full charge of this work in the State, selecting a superintendent, auditing accounts, etc. This board made M. F. Greeley, of Gary, superintendent of institutes, and empowered him to hire such assistants as he deems necessary to effectually prosecute the work

It has been decided to hold an institute in every county in the State during the present year, the same to be held at the most accessible point in the county, presumably the county seat in most cases. During the month of July institutes were held in the six counties of the Black Hills. The attendance at these meetings averaged 173 to the session and 519 to the institute. It should be remembered that homes out here are scattered. Many farmers drive from 20 to 40 miles each way, and when weather is stormy and roads bad it almost does away with the meeting.

In addition to these meetings we have up to December 8 held 13 meetings east of the Missouri River. Most of these have been single-day meetings with evening session, and have been well attended. The force consists of four speakers, including the conductor. While the experimental work of the agricultural college will be ably represented by one or two of the workers there, it is intended to confine the speaking largely to strictly practical men, who come directly from their well handled stock and farms to the platform.

It is proposed to have the home well represented, and the meetings are made interesting to women and young people as well as to men. Particularly are the evening sessions and the latter part of the afternoon sessions arranged with this object in view. At the summer meetings demonstrations in cooking were given in the morning in a separate hall, but in the winter meeting this work is restricted to talks on plain foods, right living, and home making by Mrs. Bertha Dahl Laws. It is proposed to carry out this plan throughout the entire year's work, so as to insure at the start the equal representation of the work of the home with the work of the farm.

UTAH.

By P. A. Yoder, *Logan*.

Our State legislature has made appropriations of $1,500 annually for the farmers' institutes. From this appropriation are paid the traveling expenses of the speakers and the incidental expenses in holding the meetings, in advertising the same, in securing office and stenographic help, and in the publishing of a Farmers' Institute Annual. The lecturers work without pay from this fund.

The management of the farmers' institutes is vested in the faculty of the agricultural college. A committee of this faculty is appointed by the president, of which the director of the experiment station has thus far always been chairman. This committee has the immediate charge of the work and corresponds with the officials of local organizations, or where no local organizations exist, then with prominent citizens, to arrange for the calling of meetings. The law requires that at least one institute be held in each county each year. The fact that the settlements in some counties are so far from the railroads, and that the railroad and stage fares are high, makes it both time-consuming and expensive to reach all counties each year. Most of the institutes are held during tours, in each of which a number of places are reached. The most opportune time for these tours is during the week between Christmas and New Year's, when our absence from college least interferes with that work. We, however, do not limit ourselves to any particular time in the year for these tours. We are often enabled to lessen expenses considerably by combining farmers' institute work with our regular inspection trips to the outlying experiment substations, of which we now have provision for eight, viz, six arid farms, a southern Utah experiment station, and a central Utah experiment station.

Two or three speakers from the agricultural college are usually sent on each of these farmers' institute tours. Practically all heads of departments on the experiment station staff have been thus called on to participate in the work of the farmers' institutes, besides many of the assistants and other members of the college faculty. Among the latter I desire to mention especially our professor of domestic science and her assistants. Their work among the women at the farmers' institutes has been productive of much good.

Where possible to find local speakers to help in the meetings, we encourage such participation. Usually a considerable part of the programme is given up to questions and answers, or discussions which such questions evoke.

The lines of work touched upon are too varied to enumerate here, but those touched on most frequently or presented most extensively are arid farming, duty of water, alkali land reclamation and prevention of alkali troubles, organization for grading and marketing fruit, combating the codling moth and other insect pests, the dairy industry in diversified farming, and the application of thoughtful and scientific methods in household economy.

There have been no distinctly new lines of work introduced, but a few features in which we diverge somewhat from previous years are, first, we have held more county institutes as distinguished from meetings in the individual small settlements; second, we include in the Annual more nearly the exact addresses given and the questions and answers as presented; third, at the State fair this fall we joined with the experiment station exhibit some farmers' institute work by delegating several members of the station staff to explain and elaborate on the things there exhibited to the visitors as they pass along or congregate around the experiment station booth.

Personally, I am impressed with the advantages in the arrangement, whereby the members of the experiment station staff and the agricultural college faculty thus get out into the various farming communities. There accrue from it reciprocal benefits that far overbalance the inconveniences resulting from some interruption in the regular work at the station and college. Hardly any other one thing gives us as good means of learning what are the live problems confronting the agriculturist, or what presentation will make the theoretical and experimental deductions most useful to the farmer.

VERMONT.

By George Aitken, *Woodstock*.

According to Vermont law, we are obliged to hold at least one meeting in each county every year. During the months of December, January, February, and March we held 40 meetings. Average attendance, 125; amount of money spent, $1,882.05; number of speakers employed, 17. We find the best results from working in connection with the Grange and in the back towns, remote from railroads and large cities. New lines of work taken up last winter were "Alfalfa for eastern farmers" and "Agriculture in our rural schools."

VIRGINIA.

By A. M. Soule, *Blacksburg*.

During the past year the farmers' institute work in Virginia has gone steadily forward; probably it marks the inception of the real development of farmers' institute meetings as understood and appreciated in many of our States. From September 1, 1904, to September 1, 1905, more than fifty meetings were held in widely scattered sections of the State, eight out of the ten Congressional districts being visited.

The amount of money appropriated for farmers' institute work amounts to $5,500. A member of the State board of agriculture is appointed from each Congressional district, and $500 is apportioned to each man. There is also an ex officio member of the board who has $500 at his disposal, and he has seen fit to turn this money over to the defrayment of the expenses of the annual meeting of the Virginia State Farmers' Institute. The $500 given to any Congressional district is at the disposal of the member therefor, and in most instances the members have seen fit to spend their quota.

The number of speakers employed at the meetings has never been over four in any case. As the work is so new in this State it has been difficult, if not impossible, in many instances to get local speakers, and the brunt of the battle has fallen on the shoulders of the experiment-station men. As a rule, two men from the station attend a one-day institute, and where two-day meetings are held two or three and sometimes four men go.

The most of the meetings held so far have been largely organized and advertised through the efforts of the administrative officer of the station. As a rule, the application has come to the director of the station and he has corresponded directly with the member of the State board interested and asked if it would be agreeable to him to have meetings arranged for in his district. Meetings have been held in series to cheapen the cost. An advertising agent has been sent out in advance to visit the county towns where the meetings were to be held and interview the newspapers, put in notices of the meetings, and have programmes printed and distributed. The county superintendent of instruction has been approached and asked to have the teachers announce the meetings. Posters have also been sent to the postmasters, to the school-teachers, and put up in all the public buildings and stores in the county town and adjacent ones as well. In this way a general interest in the meetings has been aroused, and the attendance has been remarkably good considering the newness of the work. Fully 8,000 farmers were present at the meetings held the past year.

No new lines have been inaugurated. The plan outlined has succeeded remarkably well, considering that little systematic effort has been made along institute lines previous to this time. Our farmers are anxious to learn and attend the meetings willingly when they believe some information of value is to be obtained. The principal subjects discussed were as follows: Soil renovation and improvement, the purchase and utilization of commercial fertilizers, live-stock diseases and their treatment, selection and improvement of corn and other cereals, and the feeding and nutrition of farm live stock. As a result of the institute work a new interest is evidenced in agriculture. This is shown by the large increase in the correspondence received at the station. There is also a greater demand for literature relating to agricultural subjects, and there is a growing interest in the introduction of agriculture in the public schools of the State.

The round-up meeting held in Roanoke last July was highly successful, more than 500 farmers attending from all sections of the State. An excursion was planned to the experiment station at Blacksburg and practically all the delegates attended. They were highly gratified and delighted with the work in progress at the station and indorsed all the efforts being made to obtain information of value to the farmers of the State through the researches now in progress at the station. The interest in the work continues to grow and plans for this year are being undertaken on a much more comprehensive scale with the belief that the results in the future will be more gratifying than in the past. There are certain defects in the system which are appreciated by those connected with the work, and in the course of time these will no doubt be remedied. There is a growing interest in farmers' institutes. Our farmers realize the necessity and value of agricultural education, and are becoming insistent on their rights to receive the attention along educational lines which the importance of their industry makes imperative.

WEST VIRGINIA.

By J. B. Garvin, *Charleston.*

About four-fifths of the institutes are held before the late fall months, in order to avoid the possibility of interference by bad roads. In sections where the farmers are more highly favored with macadamized roads the institutes are usually held during November, December, and January. For this reason our report gives a part of the work in 1904, as well as 1905. During the period mentioned 83 institutes have been held. Forty-seven were one-day institutes of two sessions each, and 36 were two-day institutes of six to eight sessions each. In some instances the two-day meetings were arranged to begin at noon the first day, which accounts for the difference in the number of sessions for the two-day institutes.

We have always endeavored, in so far as possible, to secure an accurate account of the number in attendance at each institute, but we have not been able to accomplish this in every case. The number given as the attendance, partly estimated and partly by actual count, is 13,183. This hardly measures up to the estimated attendance of former years, but it is not entirely due to lack of interest, for some of the largest attended and most interesting meetings have been held this season that we have recorded in the history of the institute work in the State. In all, fourteen speakers were employed. As a rule two speakers were assigned to each institute. The total cost of institutes for the fiscal year, not including the salary of the superintendent of institutes, is $2,375.35. The expenses are paid by the State board of agriculture out of the funds appropriated for the use of the board.

Among the special features that might be mentioned is what we term schools of agriculture for the farmers. Two of these schools have been held during the year in two different counties, instead of the regular annual institute. In one county the school was held for six consecutive days, and the instruction imparted consisted of various subjects of interest to farmers. The other was held in a community where more attention is given to dairying by the farmers, and five days were devoted to special instruction in dairying.

Where these schools have been held great interest has been manifested and the farmers have asked for a continuance of the school rather than hold a two-day institute. The board furnishes two instructors and the average cost of each institute, and the farmers attending the school pay for any additional instructors they may wish to have.

The work of the superintendent of institutes has been mostly confined to the office, but it is proposed that hereafter he shall devote a part of his time to field work, in order to establish better local organizations, for herein lies to a very great extent the success or failure of the farmers' institute.

WISCONSIN.

By George McKerrow, *Madison.*

During the past year we held 81 meetings lasting two days each and 1 meeting lasting three days. The number of speakers employed was about thirty. Our plan of campaign was to cover the State as evenly as possible, so that each farmer in the State could reach a meeting without having to travel too far. No new lines of work were followed, but some of the old lines were enlarged upon, especially such as lawful milk, cleanliness in dairy products and their manufacture, the growing of alfalfa and sugar beets, and sheep husbandry. The old topics, such as all phases of dairying, horse breeding, swine breeding, horticulture, road building, production of poultry products, health of our animals, especially as it deals with the question of tuberculosis, home life, domestic science as it relates to the cooking of foods, agricultural education, and the rural schools, and in fact all of the topics that we have been able to think of in relation to improving the farm home, the best farming and the development of the farmer and his family, have been discussed. We have issued and distributed the annual Wisconsin Farmers' Institute Bulletin, 60,000 copies of a 320-page handbook of agriculture, covering the above-mentioned topics as discussed at the farmers' institutes, with a full report of talks, questions, answers, and discussions at the three-day closing institute meeting.

REPORT OF THE FARMERS' INSTITUTE SPECIALIST OF THE U. S. DEPARTMENT OF AGRICULTURE.

By John Hamilton, *Washington, D. C.*

Institutes have been held during the year ended June 30, 1905, in all of the States and Territories of the United States, excepting five—two States (Florida and South Dakota) and three Territories (Alaska, Indian Territory, and Porto Rico).

Reports for the year, giving the condition of the farmers' institute work, have been received from all of the States and Territories holding institutes, except four—Missouri, Tennessee, Rhode Island, and Vermont.

Forty-two States and Territories report 1,714 one-day institutes, 1,262 two-day institutes, and 120 three-day institutes—a total of 3,096 institutes, composed of 10,153 sessions.

Forty-one States and Territories report a total attendance of 977,082. Thirty-seven States and Territories report appropriations by the State and Territorial governments for institute purposes amounting to $197,082.13. Appropriations for the year from other sources amounted to $20,056.76. The total cost of the institutes was $204,975.79. The appropriations for the coming year (1905–6) as reported by thirty-six States, amount to $208,907.62.

Forty-five States and Territories report 992 State lecturers upon the State teaching force. Three hundred and thirty-eight of this number were from the faculties of the agricultural colleges and the staffs of the experiment stations. These officials contributed 2,622 days of time to teaching in institute meetings. The whole number of days of institutes reported is 4,598.

Assuming that the four States that have not yet reported have held their own in all respects, we have by adding the items in their reports for the year ending June

30, 1904, to the above totals a considerable advance in institute activity in all directions. The figures corrected by the addition of the data as given in 1904 for the four States mentioned show that there were 1,935 one-day institutes held during the year ending June 30, 1905, an increase of 180 over the previous year; that there were 1,317 two-day institutes, a decrease of 159; and that there were 123 three-day institutes, an increase of 48; that the total number of institutes was 3,375, an increase of 69; that the total number of sessions was 10,810, an increase of 188, and that the total attendance was 1,027,022, an increase of 185,324.

The appropriations by the States increased $11,466.01 and the appropriations from the colleges and other sources increased $9,257.10. The total cost of the institutes was $219,541.04, an increase of $16,474.48. The appropriations for the coming year of 1905-6 amount to $232,847.62, an increase of $9,683.62 over that of the year ended June 30, 1905.

There are 992 State institute lecturers, an increase of 39. Three hundred and sixty-six of these lecturers were from the faculties of the agricultural colleges and the experiment station staffs, an increase of 5. The college and station lecturers contributed 2,646 days of time, an increase over the previous year of 515 days. The total number of days of institutes was 4,938, an increase of 95.

The Department during the year issued a number of publications relating to the institute work; a bulletin on Agricultural Instruction for Adults in the British Empire; also a number of syllabi of lectures on agricultural topics accompanied with lantern-slide illustrations. The list of State directors has been revised to September 1, 1905, and a new list of 1,581 names of local managers of institutes has been secured, all of whom are being supplied with institute literature. Bulletin No. 135, entitled "Legislation Relating to Farmers' Institutes," has been revised, brought up to date, and is about ready for distribution. Several courses of study are being prepared for use in movable schools, one on cheese making, one on butter making, one on poultry rearing, and another on fruit growing. Each course will require about fifteen days to complete. Each lecture is accompanied by a practicum, which each student is expected to take, which will occupy from one hour and a half to three hours of time each day.

A bulletin entitled "Agricultural Instruction for Adults in Foreign Countries" is in the hands of the printer, and another giving a history of the origin of the farmers' institute work in each State and Territory has been prepared.

Morning Session, Friday, November 10, 1905.

The convention met at 9.30 o'clock a. m., the vice president, Mr. E. A. Burnett, in the chair.

Resolutions.

The committee on resolutions, consisting of F. H. Hall, of Illinois, John Hamilton, of Washington, D. C., and H. T. French, of Idaho, reported as follows:

COMPUTING ATTENDANCE.

In view of the inaccuracy and misleading character of the method now in use by this association for computing institute attendance; Therefore be it

Resolved, First. That hereafter the number in attendance at each session of each institute shall be ascertained by actual count and recorded, and the aggregate of all of the sessions shall be reported as the total attendance for the year. This aggregate divided by the number of sessions shall be regarded as the average attendance at each session.

Second. That attendance at the annual round-up of institute workers, outdoor picnics, harvest home meetings, and similar assemblages of farmers addressed by institute speakers, shall be reported separately from the regular institutes, the total attendance for the entire meeting to be given instead of the number present at each session.

STANDING COMMITTEES.

Resolved, First. That standing committees be created, consisting of three members, to be nominated by the executive committee upon the following subjects:

(1) Institute organization and methods.
(2) Institute lecturers.

(3) Cooperation with other educational agencies.
(4) Movable schools of agriculture.
(5) Boys' and girls' institutes.
(6) On women's institutes.
(7) Legislation.

Second. That it shall be the duty of the standing committees to consider during the intervals between the annual meetings of this association the subjects severally assigned, and report the results of their investigations to the annual meetings of the association, accompanied by such recommendations as they may deem proper to present.

FEDERAL SUPPORT FOR FARMERS' INSTITUTES.

Whereas the Secretary of Agriculture is recommending to Congress an increase of the appropriation for the maintenance of the farmers' institute work of the Department: Therefore be it

Resolved, That this association expresses its gratification at the action of the Secretary, and pledges its support before the committees of Congress in the effort to secure the recommended legislation.

PLACE AND TIME OF MEETING.

Whereas we believe the best interests of this association will be advanced in insuring better attendance through transportation arrangements by meeting at the same place as the Association of American Agricultural Colleges and Experiment Stations and at as nearly the same date as possible: Therefore be it

Resolved, That the executive committee of this association be hereby authorized to confer with the executive committee of the above association in fixing the time and place of next and all subsequent annual meetings of this association, and that the by-laws of this association be so changed as to give the executive committee this authority.

MISCELLANEOUS.

Whereas the honorable Secretary of Agriculture, James Wilson, Assistant Secretary W. M. Hays, Director of the Office of Experiment Stations A. C. True, and Mr. John Hamilton, through his official capacity as Institute Specialist, have been present at the meetings of this association and taken an active part in its deliberations: Therefore be it

Resolved, That we express our sincere appreciation of their valuable services, and to all others of the Department of Agriculture who have in any way contributed to this meeting, and that we hope these interests may continue as in the past until this association shall occupy, if it does not already, a prominent place in directing agricultural education in this country.

Whereas the railroads entering the city of Washington have so generously granted reduced rates for delegates and visitors to this annual meeting: Therefore be it

Resolved, That we extend to them an expression of our appreciation of their services by passing this resolution.

The resolutions were adopted.

EXTERMINATION OF GYPSY AND BROWN-TAIL MOTHS.

J. L. Ellsworth, of Massachusetts, offered the following resolution:

Whereas the gypsy and brown-tail moths have been a great menace to the people of Massachusetts in damaging and destroying forest, fruit, and ornamental trees and shrubbery; and

Whereas they are likely to spread and become a great calamity throughout a large portion of the United States unless their ravages are checked: Therefore be it

Resolved, That we recommend or favor aid from the Federal Government for the extermination of these pests.

The resolution was referred to the Secretary of Agriculture for such disposition and action as may seem proper to him.

Election of Officers.

W. L. Amoss, of Maryland, read the report of the committee on nominations, consisting of W. L. Amoss, E. E. Kaufman, of North Dakota, and F. H. Hall, of Illinois, as follows:

Your committee on nominations reports as follows: For president, G. C. Creelman, of Guelph, Canada; vice-president, W. W. Miller, of Ohio; secretary and treasurer, John Hamilton, of Washington, D. C.; executive committee, J. G. Lee, of Louisiana; F. H. Hall, of Illinois, and W. L. Amoss, of Maryland.

The report was adopted and the officers named declared elected.

At 11.45 o'clock a. m. the association adjourned until 8 o'clock p. m.

At 12 o'clock noon the members of the association were received by the President of the United States.

Evening Session, Friday, November 10, 1905.

The convention met at 8 o'clock p. m. at the National Hotel, the vice-president, E. A. Burnett, in the chair.

W. M. Hays, Assistant Secretary of Agriculture, was introduced, and spoke as follows on the subject of consolidated schools:

CONSOLIDATED RURAL SCHOOLS.

The United States has been a remarkably fertile and an extensive field for experiments in systems of education. For city life three classes of schools, articulated into a unified whole, have well-nigh occupied the entire field. Elementary education for nearly all city and village pupils has been supplied by the city graded schools; the city high schools provide secondary education of a general character to large numbers and industrial education and technical education to a small number. State universities and State colleges, except in the older States, have become the distinctive institutions for the higher technical and professional learning of that comparatively small number who enter the professions. The public graded schools are supplemented by parochial and private schools; the high schools are supplemented by academies, business schools, and other institutions of secondary grade, and the institutions for higher learning are supplemented by universities and colleges not supported by public funds.

Education in the primary graded schools is taking a somewhat more practical turn, as is indicated in the development of nature-study courses, manual training, and industrial work. Public high schools are giving more attention to the practical affairs of the city life. Our institutions of higher learning are paying more attention to the preparation of teachers for instruction in practical lines in the secondary and primary schools, and there is a tendency all along the line to give more time and attention to the industrial and technical work which nearly all city-born people must of necessity engage in.

A system of schools for country-life education was started when Congress passed the act which resulted in the establishment of land-grant colleges of agriculture and mechanic arts in each State. Thus taking the lead, Congress turned the attention of educators toward specific instruction for those who are to manage farms and farm homes. These agricultural colleges, planted among the old-line institutions of the country, are requiring half a century for their organization so as to lead efficiently in country-life education. A goodly proportion of them have already reached a permanent status in their work and are turning out both agricultural technicians and a fair number of farmers technically educated for their business. Under some of these colleges a system of agricultural high schools is being developed, also numerous short courses, but the movement to carry some of the more important elements of technical education along the lines of country-life affairs to the elementary rural schools has gone forward but slowly.

To be as well adjusted as are the three classes of schools for city life, the colleges of agriculture, agricultural high schools, and rural schools, both consolidated and isolated, need to be articulated into a unified system. An agricultural college in each State, an agricultural high school in each ten counties or even one in each county, a consolidated rural school in each district of 20 to 36 square miles or one isolated school in each district, will make a system, and country children will have a ladder to climb as do city children now.

Obviously, the function of the agricultural college, and even of the agricultural high school, can never be to give technical education to the farmers as a whole. These institutions can reach only a relatively small number of people. The function of the agricultural college and agricultural schools of secondary grade in relation to the whole number of those who are to farm must be mainly that of preparing teachers and leaders. But this is a most important function, and these institutions are gradually rising to successfully meet the problem. They must be greatly increased in size to prepare a sufficiently large number even for teachers.

Elementary schools, university extension work, books, and periodicals must be the main agencies for bringing industrial education to the great mass of the people who do not go beyond the elementary school. The rural school is the greatest agency through which to work because it reaches practically all of the youth who are to form the ranks of the farmers in the coming generations.

Steps that will better prepare the rural schools for giving agricultural instruction, and that will put into pedagogical form that body of thought which is being rapidly wrought out as a suitable basis for such instruction, have the widest significance.

The little rural school which has had such a wonderful national influence has not proven well adapted to taking on lines of instruction related to country industries. These studies have two requirements not well met by the little rural school. They can not be given without some equipment, and teachers especially trained in agriculture and home making are a prime necessity. The consolidated school as developed in northwestern Ohio and in other sections of the country, as compared with the little rural school, offers greater advantages as an institution into which to introduce industrial work.

Farming communities producing sufficient wealth so that with some State aid they can provide good school equipment and superior teachers and can pay the cost of hauling pupils to and from school can not afford to overlook the advantages of rural school consolidation. Here the first requisite, a teacher trained not only in the common studies but in agricultural subjects, can be afforded, usually as the principal of the school. An assistant trained in home economics is also within the range of financial possibilities. The better grading of the school also affords an opportunity to find a place and time for the introduction of technical subjects. A larger school building makes it possible to find a place for doing laboratory work and practice work. Larger grounds and their equipment may also be provided. Plants, school gardens, orchards, and even small field plats can be had for demonstration and instruction purposes. Simple laboratory apparatus can be afforded for instruction in both agriculture and home economics.

When viewed as a whole, only a part of this country and Canada can hope to support the consolidated rural school. In all thinly populated sections, and in sections where the soil does not produce abundantly, the higher cost of the consolidated school per square mile will make it impracticable to change from the isolated school. While the problem of introducing special country life subjects into the little rural school may remain the larger and more important problem because it applies to the larger number of pupils, methods of carrying this instruction to the lower schools may best be wrought out in schools with somewhat better organization. It may be that many of the teachers in the little rural school can be in part trained in the larger rural school, as well as in county and State schools of agriculture and in normal schools, provided with more or less of instruction in agriculture and home economics.

There are vast regions where the appropriation of money per square mile for the support of consolidated rural schools will several times over warrant the additional expense. No universal plan can be adopted. Generally speaking, there should be a plat of land, say 5 or 10 acres, a schoolhouse of three to five rooms, a principal's cottage, and small outbuildings. The land might properly be divided with 5 acres for field crops and 5 acres for campus-like area for buildings, shelter belt of trees, plantations of trees and small fruits, gardens of vegetables and flowers, and also ample playgrounds. The principal should be trained to give instruction in agriculture, and one of the assistants should be trained to teach in home economics. There should be collected some apparatus in the building for technical instruction, and a library concerning rural affairs and home making adapted to the needs of the adults of the community, as well as to the pupils, should be built up. Not a small part of this could be made up of publications from national and State departments of agriculture. And if a large number of centralized rural schools were so organized as to make good use of such publications, their numbers could no doubt be increased and in some cases designed for specific use by such schools.

The plantations of trees, vegetables, and ornamental plants could be made to serve a most excellent purpose for instruction by demonstration and practice methods. The pupils could be taught how to grow many things of which they would never learn on the home farm, and they could be trained to do many of the manual operations commonly done on the farm in a much more effective manner than they would be taught at home. On the land set apart for field crops lessons could be taught in farm management, crop rotation, fertilizing the soil, and methods of preparing the land and of planting, cultivating, and harvesting field crops.

But the most valuable opportunities are those where the school and the home and farm can be brought into cooperation in the training of the child. The plan of the child's home farm, the methods of handling each crop, the manner of producing each class of animals, the management of the general housework, the decoration of the home, the cooking and the sewing, all are lines of work in which ways of bringing cooperative action between the teacher and the parent may be introduced into the training of the child. How this may be done has not been worked out in detail, and no doubt, even after a large amount of instruction has been published along this line, the local conditions surrounding each teacher will require the constant devising of new ways and means.

This instruction will connect the school life with the home and farm life. It will give to the education a practical realistic turn, which, while avoiding the bookishness of education, will lead to placing a higher value on books. Not only will technical books be better appreciated by the pupil, because the school will be more practical, but this connection of school work with actual things will give greater stimulus to all school work. Parents will be more willing to have their children remain for a longer time in the school that will give them training in practical affairs, and this longer period will provide more time for the general and cultural studies and give the pupils a larger experience among people. One of the great advantages of the larger school is that the pupils have more training with folks. They are not subjected to the usual isolation of the farm at so youthful an age.

These schools can better be made centers of social and other activities than can the little rural school. Here the grange and farmers' clubs can center, and lectures and meetings for various purposes can be held in the school with two of its rooms opened together forming a hall. Modern stereopticon and moving-picture devices make it practical to give much instruction in agriculture to pupils and adults where such places for meetings are available. The vans used for conveying the pupils to school can be utilized to collect people for meetings. Contests at athletic games between schools will extend the acquaintance of pupils beyond their own district. One of the advantages of the larger district is that pupils during their school age become acquainted with hundreds instead of with only scores of their neighbors. There is a wider acquaintance from which to choose friends and lifemates and a wider knowledge of people with whom to do business.

Schools thus organized with teachers technically trained would rapidly develop methods and would devise ways and means of giving practical instruction, meanwhile the larger and more highly organized school would be better developed in general education. And the county inspectors having fewer schools to visit would be far more effective than now in building up corps of teachers, in securing good methods, and in developing a public sentiment more loyal to a splendid school system. With the development of teachers trained in country-life education there will be available those especially successful, who, as county inspectors, can help to create a new curriculum and a new spirit in our rural schools.

Every farm community which has productive land should investigate the practicability of consolidating their rural schools on some such plan as outlined above. And every rich State should carefully consider giving large State aid to this class of schools. Possibly the State could undertake to pay for the purely industrial features as it pays for the special education of those who attend the State institutions of higher learning. It might be a good plan for the State to assume the cost of technical education in city high schools also. The consolidated rural school course can be extended to the end of the second high school year, as has been amply proven by the experience of consolidated schools already existing, thus making it practical to introduce much technical instruction.

There are needed numerous experiments on a not too expensive scale to determine lines that are practical in developing country-life education in rural communities. Those in Canada, Illinois, Wisconsin, Minnesota, Alabama, Tennessee, and elsewhere are pointing out many difficulties and are developing numerous successful features, more or less applicable in the consolidated rural school, and some of them will be helpful in the isolated rural school. The texts, the laboratory helps, the leaflets, the correspondence course, the children's nature clubs, and other devices of bright teachers and promoters are all bringing forward the movement for better and more practical education in rural communities. The consolidated rural school, where the expense can be borne jointly by the locality and the State, thus makes it possible to introduce more of the studies in agriculture and home making. It can not be hoped that a sufficient number of those who teach in the isolated rural schools will be trained to teach these practical subjects. Where six or eight schools are consolidated into one, only one teacher is needed who knows how to teach of the farm and one of the home making.

The supply of teachers so trained for even this small number of schools will be short, and the combined efforts of all schools which teach agriculture in long courses, in short courses, and in special teachers' courses will be required to furnish such teachers in response to a normal and healthy growth of the consolidated movement.

The opportunity to serve his community which is offered to the principal of a consolidated rural school organized as above should not be underestimated. The tactful teacher who can unite all the available sources and use to advantage all the facilities of the school and of the farm community, and who can be a leader in the industrial thought and plans of the community, can do much to establish country life on a better basis. The teacher who thus has the opportunity to lead in the thought relating to the making of country homes also should not underestimate her opportunities. The higher standards of farming and of country living once established will be kept alive by custom. Modern advancement needs this better agency to bring more rapidly to the farm and the farm home the results of the world's genius.

Districts with lands not sufficiently productive to support consolidated rural schools will be greatly benefited by consolidation where consolidation is practicable. Not only will the centralized school serve as a place in which methods of teaching rural industry will be so worked out that much of this work can be placed in the smaller rural school, but these larger schools with longer and more complete courses of study will do much toward supplying teachers so trained that they can successfully teach the special as well as the general subjects in the smaller schools.

Those who are so situated that they can experiment with instruction in rural schools, who can devise new methods, and prepare and publish helps, have most important opportunities. The successful elementary texts which may be sold in hundreds of thousands or millions of numbers is a most important agency. The pioneer who may work out the basic plans for managing rural school gardens will have the satisfaction of having done a most useful work. Those who make material advancement in devising plans under which the rural school-teachers and the parents can make the home duties a part of the school instruction will have done most worthy service. Those who successfully arrange normal and secondary school courses which combine education in general studies, in technical subjects, and in normal training so as to provide a competent corps of teachers for rural schools, centralized and isolated, will have done the greatest service of all. If the next forty years witness as great advancement as has been seen since the first agricultural colleges were started forty years ago, we shall have instruction in agriculture and home economics placed on an even basis with education in any one of the three R's. Even the mountaineers will have some knowledge of the soil, of the plants they grow, and of the animals they use. They will have the three R's keys to knowledge, and will share in the flood of treasured printed matter on all phases of life, including their own environment. The mountain sides will yield them more bread and more meat, and the mountain home will take on more of the modern spirit and be supplied with more of modern conveniences. The farms in the regions of rich soils will continue to develop as they have developed in the past forty years, and American country life will grow and keep apace with the better side of our city life.

Our national and State governments have done much toward formulating and directing country-life education. Funds from the larger public organizations can have two functions. It can help to actually pay the cost, and it can be judiciously handled so as to encourage the larger more local organization, as the county or the local district, to supply more funds and to use it in more practical lines.

The consolidated rural school movement is of prime importance in districts with rich lands, because consolidation makes possible many other things, including the enrichment of the soil, making larger the net profits per acre, and giving above all this a broader civilization, better homes, and a better crop of young men and young women to become managers of our farms and farm homes, with a small surplus to be sent into city life.

F. H. Hall, of Illinois. We have only one single instance of school consolidation in the State of Illinois, and that was only brought about after many years of effort. The county superintendent, of whom you have all heard, I am sure, Mr. Kern, went over into Ohio and took with him two people at least from his own county, one of whom was opposed to school consolidation; and while he had him over there he got him converted, and he went back and established the school. I can not speak now as to the numbers, but there are at least 25 per cent more pupils in attendance from the same territory than were in attendance under the old plan, and they have two years of high school where they had none before; and the cost only slightly exceeds the cost of the schools as they were organized before. I think I may say it is true that almost unanimously the people now approve the plan; and yet we are finding great difficulty in organizing such schools in other parts of the State. We have formulated a plan for that purpose, and hope to bring about good results.

H. T. French, of Idaho. We have a large tract in the southern part of the State, of some 200,000 acres, which has recently been brought under irrigation. This land was withdrawn under the Carey act, and was nearly all sold and is being settled rapidly, and the company reclaiming the land has set aside 5 acres in the center of five different townships in this tract for the purpose of building township schools. Those schools are some of them under construction, and they will all be soon completed and they will be the only schools that we have. The idea will be to bring the pupils to the schools, which will be graded schools, in a measure, and which will teach agriculture. Our State superintendent is entirely in sympathy with the idea of teaching agriculture in the public schools, and we have succeeded in putting some leaflets in the State course of studies. That is an experiment to some extent, but it is being watched with interest, and I am sure it will result in much good and that the consolidated school system will be established, at least in our State.

G. C. Creelman, of Ontario. I would like to say one word and for one reason only. My children attend a consolidated school, the only one we have in our Province, and we are all so well satisfied with it that I do not think there is any danger whatever, although it is only on a three years' trial, that we will go back to the one-room school. We have a radius of about 5 miles. The farthest families are 5½ miles away, but the majority are within the 5-mile limit; and the children come in every morning and go out to their homes every afternoon after 4 o'clock.

When we went about among the one-room schools asking for the lists of children we found there were 95 in all in school attendance, on the average, in those five-school sections all put together. Those one-room schools were being conducted very largely by young lady teachers, some of them very young ladies, not getting, some of them, more than $300 or $350 a year for the work. After consolidation, much to my surprise, there came to the school on the day it opened more than 150 children from those sections; and to-day, out of the same five sections, there are, although we opened only in November a year ago, over 200 in actual attendance.

Now, in finding out just exactly how that came about, we discovered that children who had quit school one, two, and three years ago, and some of them as long as five years ago, were coming back to the graded consolidated school to finish their education, because with the more experienced and skillful teachers they were able to get additional benefits which had been impossible when the teacher in the schoolroom was some young girl, herself not out of her teens and hardly out of her fifth book, who had come back to teach them.

Then the little tots from 5 to 8 years old are coming. I live up in what is called sometimes the frozen north; I live in Guelph, Canada. In January, February, and March of this year there were 22 children in the primary grade there who did not miss a day, some of them coming 5 miles to school every morning. Most of these little tots would have been shut out entirely from the one-room school, where they had to go a mile or a mile and a half through the snow and on foot.

The only thing that will ever throw out the consolidated school is the expense, which has proved to be greater than was ever anticipated. When you take the cost of hiring teams at from $2 to $3 a day every day, or five days a week, and sending them out to bring in the pupils, in addition to the better salaries you have to pay teachers if you want a better school, and add all that to the cost of the consolidated school itself, it is not perhaps more than the cost of the five schools used to be; but the cost of the teams and hauling, and the cost of the better transportation you engage, is going to make it so expensive that in our country the average farmer is going to have to be coerced or driven into the consolidated school. As a matter of fact, we have been getting education in the country places too cheaply. The average that was paid toward the school fund by the farmer was so small that it was practically nothing. And now Sir William McDonald, whose name was mentioned yesterday, is going to put up all the money except what they have been paying in their taxes and in the individual schools. He is now putting up the difference between what they have paid and what it will cost for the consolidated school. He is going to go down into his pocket for that money for a five-year experiment. Each child has a little farm of its own in the school yard. This feature worked so admirably that the children of our consolidated school to the number of 200—the vote being unanimous—decided to come back one day a week during the summer vacation to look after those little farms rather than have them neglected during that time. I do not think you could have any better test of the value of that work than just that illustration, that those children would come back during their summer vacation to do that work in that way.

George Aitken, of Vermont. While I was in Mexico I saw something that struck me forcibly. Just at the close of the school hours we met on the streets bands of children, the girls with the female teachers attending them, and the boys attended by the male teachers; and upon inquiry I found that they were looking after them to the train. They saw them safely to the train, and they were distributed to their homes at the various stations. I thought that was an ideal condition, perhaps much ahead of anything we have had here. I know nothing of the conditions in the shools there, but I thought that was to be admired.

O. C. Gregg, of Minnesota. In our own district consolidation has but just commenced. I could say more about the difficulties in organization than I can about the effect of the schools. We had to face the expense of new buildings, and we had no individual who would put up the money. We had first under our law to hold a meeting first in one district and then in the second. We went up with a majority of about two-thirds, and then as people came to look at the system it grew in favor. The schools started this last fall, and we find that we have an increased number of pupils. Of course we have the benefit of the grades. We find, also, some of those who opposed this union of these two districts, making about half a township, saying that they never would send to the school, arranging of themselves to bring the pupils to the schoolhouse. And in the northwest, where the creamery interest is a large one, and we are sending our cream to the stations, it looks now as though there would be a combination of hauling cream and children: and in that way, you see, you get the cream of the farm in two ways and both kinds just where you want them.

A. J. Kahler, of Pennsylvania. I will venture to say that in all the districts of Pennsylvania you will find that when the boys get to be 9 and 10 years old, if they have any aspirations for education, it is considered necessary to send them to boarding schools, and in that case you have the expense of traveling and all the other incidental expenses, which you do not have in these consolidated schools.

Suppose you do increase the expense? I see a good many old men here and I will ask you, How did we use to farm? Why don't we farm that way now?

Just one more word I want to say. The majority of our children go to the cities to the boarding schools at a tender age, when they need parental care, and to my own knowledge many of them come home neither ornamental nor useful. In these consolidated schools they can be educated at less expense, and they will be more healthy, physically and morally. I know in my own district I can call to mind several of us who have paid out enough to educate our children, over and above what it would cost us in the consolidated schools, to have built the schoolhouse and still save money. We consider all the items of cost in other things, and now, in the name of common sense, let us consider them also in this.

Tait Butler, of North Carolina, presented the following paper:

INSTITUTE LECTURERS.

Reference to the published proceedings of this association reveals the fact that at every annual meeting three or more members have discussed the question of institute workers. Moreover, even before your programme committee assigned the discussion of this subject to me it was the most troublesome one with which I have had to deal as an institute director. Afterwards of course it became doubly so, and then when I read the discussions in the published proceedings of your previous meetings, and came to realize how thoroughly the field had been covered, my difficulties in relation to this important question became thrice magnified and increased. In short, after thinking a great deal about this subject, as all institute directors must, and then reading the thoughts of others expressed at previous meetings of this association, I could not but feel deeply the force of the trite phrase, "There is nothing new under the sun;" at least I am very certain there is nothing new in what I have to offer in this paper. But even an old question, though worn threadbare by past discussions, which is of such vital interest to the permanent success of farmers' institute work, and which has not yet been solved, is worthy of further consideration. Mark you, I emphasize the statements that (1) this is the most important question confronting those engaged in directing farmers' institute work, and (2) it is yet unsolved. In fact, I do not think we have yet made much progress in its solution. The partial solution indicated by the optimistic reports of directors in certain States and provinces seem to me at best, when taken at their full face value, as merely a short and unsatisfactory truce with a difficulty which certainly yet remains to be met and overcome before the institute work can be said to be on anything like a sound and satisfactory basis.

Methods, as they relate to organization, advertising, the manner of conducting institutes, etc., have been of great importance and much progress has been made toward the solution of the problems involved, but all are secondary to the necessity for supplying suitable institute lecturers. A lack of interest in the institutes on the part of farmers is sometimes complained of; but really the wonder is not that the farmers have taken little interest, but that they have taken as much interest as they have, when we consider the sort of material that has sometimes been given them by would-be institute lecturers. It seems to me we have been too much concerned with the work of getting out a large attendance to devote sufficient attention to the more important matter of furnishing those who did come out with the right sort of information in an acceptable form. By far is it better to have twenty-five farmers carry away from an institute something of real value to them and to have them favorably impressed with the knowledge and practical good sense of all the lecturers than to have two hundred go away with a lack of respect for the judgment of the lecturers, no matter how thoroughly they may have been entertained by music, declamations, and other side-show attractions.

The purpose of this discussion is, no doubt, to aid, if possible, in solving the difficulty of supplying an adequate number of the right sort of institute lecturers. The question naturally arises, therefore, What is the right sort of institute lecturer? The diversity of opinion regarding this question is great and the standard is by no means well defined. Not infrequently institute directors and institute audiences express the idea that the so-called scientific men are not wanted, but that the demand is for real, practical farmers for institute lecturers. Personally I do not care where the institute lecturer comes from, and I do not believe institute audiences do either. At least, if they do to any great extent, I believe institute directors are largely responsible for the fact. The demands of institute audiences are in a measure the result of education—they are largely what we have made them. At first the institute lecturers were largely drawn from among college and station men, and now the tendency is to the other extreme—to the so-called practical farmer. This is unfortunate, for if either class was to have been employed exclusively or to a highly preponderating extent the order should have been reversed. The farmer should have preceded instead of followed the college and station men. But the most serious mistake was in trying to do a large part of the institute work with college and station workers. To supply the demand it became necessary to employ all the college and station force when not more than one out of ten college or station or any other class of men is a suitable institute lecturer, and the other nine never should have been taken for institute work. Because a man is a great scientist or a careful and skilled investigator is no reason for supposing he is a good teacher. In fact, some of the best and some of the poorest institute lecturers I have ever known have been college and station men. Not one in fifty of the best farmers makes a good institute lecturer; then why should we expect all college and station men to be a success at institute work? The simple fact is that institute directors have been very unwise in the choice of institute lecturers, and they have recently been paying the penalty. The question is not how the man has obtained his information, but has he the right sort of information and does he present it in an acceptable manner? It is a man, a teacher, that is wanted; and if the lecturer gives the right sort of stuff in the right way he will interest and instruct and win the confidence and respect of his audience, and when he does that he is a successful institute lecturer. We hear much about the practical and the scientific man, as if the practical man could not be scientific nor the scientific man practical, when in reality good science is good in practice and good practice is good science, or, in other words, if a proposition is not practical it is not scientific. Let us be done with this nonsense; a fact is always fact; the difference is in the man; therefore, since it is the man we want, let us apply common-sense business principles in his selection.

It will perhaps be to little purpose for me to attempt a detailed description of my ideal of an institute lecturer, but before we can intelligently lay plans for securing or educating suitable lecturers we must arrive at a more uniform and definite understanding of what is most desirable.

The institute lecturer must, first of all, be an educator. The day of the agitator should have passed long ago. It is education, not agitation, that is demanded. The information given must be specific and definite; generalities are no longer of value in institute work. The institute lecturer must be accurate in the sense of correctly stating the consensus of the best opinion, but he need not regard minute accuracy as so important that he is afraid to make a definite and decided statement. It may be permissible that he be not always minutely accurate from the standpoint of the scientist, but he must always be safe from the standpoint of the farmer.

At this point please pardon me while I digress to the extent of saying that one common fault of the college and station workers as institute lecturers is that because of their custom of being accurate they confuse with too many exceptions and qualifications. For example, it is better by far to state that 30 per cent of the fertilizer value of a cowpea crop is left in the roots and stubble than to say from 25 to 33⅓ per cent, although the latter statement would be more nearly correct from a scientific standpoint. On the other hand, the chief fault I have to find with the so-called practical farmer as an institute lecturer is that he insists on giving only his own results and opinions instead of a definite statement of the average results of the best authorities, interpreted by his own experience or observation. No man's experience is sufficiently varied and extensive to make it a safe guide for the teacher, and this is especially so if, as is usually the case with this class of lecturers, his experience is interpreted by guessing, instead of by measuring and weighing. The experience of no man is sufficiently broad nor his judgment so accurate that he can afford to disregard the work of others if he is to be a safe teacher. The teacher must even avail himself of the aggregate knowledge pertaining to his subject. This the so-called practical farmer frequently can not or will not do in his institute lectures.

The institute lecturer must also be a pleasing and interesting speaker—that is, he must have a terse, incisive, forcible, and attractive way of presenting his facts. To instruct his hearers he must first interest them, but to my mind the man who must resort to funny stories and anecdote to interest an institute audience is to just that extent short of an ideal institute lecturer. Of course, illustrations by word, object, chart, and blackboard are of the greatest value, because they add to the force and accuracy of the impressions conveyed, but the tricks of the stump speaker lower the force and dignity of an institute lecture.

Since the most important part of an institute is the questions and discussions, the lecturer should be quick to correctly see and interpret the force and import of a question. Many an otherwise good institute worker fails simply because he is unable or unwilling to look at a question from the view point of the one who asks it, and consequently his answers are irrelevant and unsatisfactory. If an answer is attempted it should be direct, crisp, and polite.

Not infrequently have I heard institute directors say they wanted at least one man in each institute party who could answer all reasonable questions. Deliver us from this sort of man, I say, in or out of institute work. I want my men to be able to answer all reasonable questions in their particular lines (or to be honest enough to say they do not know), but the field of agricultural knowledge is too large for any human mind to cover accurately. You know this and so do the intelligent farmers and they consequently lose faith, just as you do, in the accuracy of any man who presumes to cover the whole field of agriculture.

The institute lecturer should be old enough to make it plain that he may have had an opportunity to do the things about which he talks. He should most assuredly have done the things about which he talks—had actual experience and observation, but, as before stated, I would not have him confine himself to this as a source of information; he would be too narrow. While it is true that any man can do good to those working in the same line, by telling them just how he made a success of any particular phase of farming, this is not enough. We must go farther than this; the institute lecturer must be a teacher in the broadest sense if he is to establish the farmers' institute as a permanent educational institution.

Now, in conclusion, how are we to obtain such institute lecturers in sufficient numbers? They are not born, but will have to be made. A few good ones may educate themselves, but enough will not. A plan must be devised whereby the suitable raw material can be converted into trained teachers.

In time the graduates of our agricultural colleges may partially supply the demand, but in many States the number of educated young men returning from the colleges to the farms is not sufficient to supply the demand for institute lecturers even ten or fifteen years hence, for not one in fifty, even of such men, will ever make suitable institute lecturers.

Is a special school connected with our experiment-station farms the only solution of the problem? I can see no other, but this solution is not an easy one. Can the institute, with our present resources, be made of sufficient value to command the money necessary to secure the services of the class of men able to develop the possibilities of this educational work? More money must be had. Even $20,000 annually spent by New York is but a portion of what is necessary to properly carry on the work in a State like North Carolina. We have been too modest in our demands. We must awaken to an appreciation of the full value and possibilities of this work and demand the money to prosecute it on a scale commensurate with its importance.

Of one thing I am most thoroughly convinced, and that is that the solution of this question of securing a sufficient number of suitable institute lecturers is the one great problem before this association and the friends of the farmers' institute work in America—the problem beside which all others are utterly insignificant.

If such normal schools, or, as I prefer to call them, training farms, are to be established, great care must be exercised in laying the plans on which they are to be conducted on correct lines, and, in my opinion, in order to meet the requirements of varying local conditions these schools will have to be more numerous than suggested by Mr. Hamilton in his able address on this subject. On one point especially should caution be great—the teachers on these farms or in these schools must be good institute lecturers as well as learned scientists. Let us not put the blind to leading the blind, as has been too frequently done in the selection of institute lecturers.

Finally, let me again say, with all the emphasis of which I am capable, that we must take a more comprehensive view of the importance of this institute work and make our demands for money commensurate therewith; and the chief reason for this is the necessity for supplying a sufficient number of efficient institute lecturers.

The following paper on the same subject by L. A. Clinton, of Connecticut, was read by title:

A successful farmers' institute depends not upon the number of people who are present, but upon the interest and attention given to the subjects under discussion. No matter how important the subjects are or what vital interest they may have to the audience, unless presented in an acceptable manner the meeting falls flat. The influence of some lecturers upon a farmers' institute is very similar to that of a wet blanket upon a fire. Just why this is so it is difficult to state, but a few general reasons can be given.

The lecturer who must confine himself to his paper does not meet with a full measure of success. While we believe that it is a good plan to have the lecture written out, yet we do not believe it a wise practice to be confined to the paper in presenting the subject. The audience prefers to have the speaker talk rather than to have him look at his paper and read what he has written.

The first element of success in an institute speaker is that he have something to say, and the second element of success is that he know how to say it. The first quality mentioned can not be acquired by studying station bulletins or literature upon the subject, but it must be acquired by actually having performed the operations discussed. The one who depends upon a prepared lecture upon stock feeding or potato growing, or any other subject, will fall far short of the full measure of success as an institute lecturer. In order to qualify as a lecturer on stock feeding, one must have actually had years of experience in handling and feeding stock. The most important part of a lecture is usually brought out in the discussion which follows the presentation of the subject. In this discussion the lecturer is at a wonderful disadvantage who has not been through the subject and learned his matter at first hand. Without doubt the pamphlets which have been printed by the Farmers' Institute Specialist of the Office of Experiment Stations will prove wonderfully helpful in institute work, yet the lecturer who depends upon them alone for his information will not prove a great success. These bulletins should be regarded as helps, and while the suggestions contained therein may prove of value, yet the subject must be presented in one's own way and the material must have been secured in a large part from other sources than books and bulletins.

In the matter of presentation it should be remembered by the lecturer that the first quality of a good speaker is to make the audience hear every word spoken. The speaker must believe first of all in the truth of what he is saying if he is to impress this truth upon his hearers.

Another quality which is of leading importance in the institute speaker is brevity. The speaker who attempts to cover the whole subject and to say the last word which is to be said upon the subject is a weariness to the flesh. From twenty minutes to one-half hour for opening the discussion is enough for almost any subject. If the audience is interested, the discussion will be continued through the asking of questions, and the audience will have an opportunity to take part in the discussion. If the audience is not interested, the quicker the subject is dropped the better. Many institute lecturers who otherwise would be rated as successful have a weakness for talking too much.

One type of lecturer which the institute manager should pray to be delivered from is the funny man. We do not object to an occasional story to lighten up an address, but where a studied effort is made to tell funny stories and the audience is kept in a roar from the beginning to the end of the lecture, the success of the institute as a school of instruction in agriculture is greatly impaired. If the funny man must appear on the programme, keep him until the last number of the evening session. We do not question the popularity of this man with the audience. He will be called for repeatedly. He will receive the most hearty cheers, and he will be given the credit of being the greatest man on the programme, but yet the farmers' institute should be for real solid business and should not be turned into a school of farce.

The energies of the farmers' institute manager in the future will be taxed to secure men with the requisite training and experience to qualify them as farmers' institute lecturers. A few of the men who graduate from our agricultural colleges may eventually be available for this work. There are few, however, who are qualified at the time they leave college. Several years must be spent in actually meeting and overcoming the difficulties in the various lines of farm work before they will be qualified to discuss intelligently the various subjects relating to agriculture.

The institute manager must be a judge of men. He must select his man not simply because of what he hears with reference to him. He should visit him at his home and should observe how his fields and flocks are cared for, and whether or not he is putting into practice the best principles. The institute lecturer who recommends one thing from the platform and who does not put into practice on his own farm what he recommends to others is an injury to the cause. Farmers are no longer taking for granted all that an institute lecturer tells them, but every year more investigations are being carried out, and the farmers are looking up the class of teachers employed in institute work. The institute lecturer must be grounded not only in the art of performing the various operations, but he must thoroughly understand the principles which underlie the art. A mere statement of how things should be done without a discussion of why one method is preferable to another is no longer acceptable. Practical agriculture and scientific agriculture now go hand in hand. There is no separating the two, for practical agriculture in order to be practical must be based upon scientific principles.

The man who has made a success in some special line of work can often be used to advantage as an institute lecturer. He may require a little polishing. It may be necessary for him to do a little reading and studying to learn what others have done in the same line and to familiarize himself with the principles which underlie his work. Then, if he possesses that quality which enables him to stand on his feet and tell in a straightforward manner what he has done, the word of such a man carries conviction.

The farmers' institute must become more and more a school of instruction, and the institute lecturer should be looked upon as one whose first duty is not to furnish entertainment but instruction. To meet with the greatest success he must in the fullest degree possess the qualities of a good teacher, a thorough knowledge of his subject, enthusiasm for his work, and the ability to speak in a clear and convincing manner.

The following paper was presented by F. H. Hall, of Illinois:

COOPERATION WITH OTHER EDUCATIONAL AGENCIES—THE COMMON SCHOOLS.

The agricultural renaissance in America had its beginning in the experiment stations. The primary function of the station is investigation—discovery. Through its bulletins it undertakes the work of dissemination. In the performance of this latter function it is handicapped. It speaks the language of science, and to the common people this is an unknown tongue. The investigator speaks to the few who can understand him, who follow him, though sometimes afar off. But they are genuine disciples and they have faith in varying degrees in their leader.

The farmers' institute attempts to organize these disciples and to send them out among the people to preach the gospel of a better agriculture. The first work of the institute is conversion. It holds up to the people some helpful, recently discovered, practical, scientific, agricultural truth. The people look upon it at first hesitatingly and perhaps suspiciously. New evidence is presented. Appeal is made to the economic instincts of the listeners, and at length some are converted—turned around—turned together with their faces toward the leaders in investigation. They begin to have faith, not in Hicks, but in the Weather Bureau; not in tradition that has to do with the moon, the planets, the number 13, and the ground hog, but in the men who weigh and measure and compare, and generalize only when sufficient data have been obtained.

The work of the institute is not so much instruction as it is inspiration. Its purpose is not so much to teach as it is to create the desire to learn. At best the number of scientific facts that can be taught in the annual institute are not a thousandth part of what the neophyte needs to learn. Two or three days of instruction per year to less than 2 per cent of the farmers in a county can not of itself have a value commensurate with its cost. The product of the number of facts learned in the best two-day county institute in North America multiplied by the number of learners in attendance is insignificant compared with the number of facts to be learned multiplied by the number that ought to learn them. If the rank and file of the farmers wait for the institute to teach them what they ought to know, all will die in comparative ignorance. The true measure of the value of an institute, then, is not so much the amount of teaching done as the degree of interest aroused. To be sure, there must be teaching, but its main purpose must be (1) to create the desire to learn, and (2) to point to the sources of information.

For the purpose of arousing interest, one interesting newly discovered fact of unquestioned economic value, so presented as to challenge attention and convince the listener of its importance, is worth a hundred commonplace truths, even though the latter may be essential and presented in a most attractive manner.

The institute speaker must give results, with just enough of the processes by which the results are secured to awaken interest and to establish confidence. Underlying principles, theories, and technical terms are essential, but the institute has done the most important part of its work when it has created the desire to become familiar with these and has pointed out the way.

But what is the way? What are the agencies that may, in part at least, satisfy the want which it is the business of the institute to create? I answer, the press, the bulletins, short courses in the agricultural colleges, and farmers' clubs for possibly the present generation of farmers; the common schools, boys' clubs, and the agricultural schools and colleges for the next generation.

I repeat, the institute at its best can do only the most insignificant amount of teaching. What it does do should be well done, and should be scientifically accurate. It should be the little morsel of knowledge that gives the thirst for more knowledge. It should be, for the most part, related to some bulletin, some book, some school, some college, where a hundred times as much as can be given in the institute may be obtained.

The institute is more a sentiment maker than it is a school. By the presentation of a few economic facts, it turns the attention of the people to the experiment station and the agricultural college, and makes generous appropriation for these great educational institutions possible.

But the agricultural college must have students, as well as money for equipment and instruction. President Roosevelt says that nearly one-half of the people in this country devote their energies to producing things from the soil. Then, I say that nearly one-half the men in college should be in the agricultural colleges. Heretofore the rural schools have been articulated with the high schools, and the high schools, in turn, with the so-called college of literature and the liberal arts. But in the State universities there are many colleges—seven in the University of Illinois. It is time that the rural schools should seek articulation with the colleges of the economic arts, particularly with the colleges of agriculture.

For a student to attempt to reach this college through the high school as it is now conducted is almost to make sure of missing it. The high school leads to the so-called learned professions. The college of literature and arts determines the high school curriculum and extends a welcome hand to its students.

It is one function of the farmers' institute to assist in finding what Superintendent Bayliss happily calls "the trail from the rural school to the college of agriculture." It must not only find existing trails, but it must help to make new ones and stimulate young people to enter upon them. It must create a sentiment in favor of teaching the elements of agricultural science in all the schools, in favor of rural school consolidation, rural high schools, agricultural high schools (or a modification of the present high school), with curricula suggested by the agricultural college and including a department of domestic science. G. Stanley Hall says that the germs and extracts of as many trades as possible must be introduced into the common schools. It is the business of the farmers' institute to see to it that the "germs and extracts" of that vocation to which nearly one-half the people of North America devote their energies are introduced into the public schools.

In no way can this be so rapidly accomplished as by the cooperation of farmers' institute officers with school officers and teachers. The combined farmers and teachers' institute is the most effective agency for bringing about this educational reform. The farmers must take the initiative in this cooperative undertaking. When the officers of the schools are made to feel that the farmers desire their assistance and cooperation the combination is easily consummated. Teachers, particularly those who know a little of agriculture, who are in touch with the Department of Agriculture and the experiment station, should be given a place on the programme. Broad-minded county superintendents of schools, in States which provide for such an officer, make first-class secretaries of farmers' institutes.

The teachers of the rural schools should be brought face to face with the leaders of the men who pay the taxes that support the schools, and these teachers should be permitted to ask the taxpayers, "What will you have us attempt in the way of agricultural instruction and training? Will you support us and give us the necessary assistance in doing the work you desire? Will you really encourage us in our attempts to obtain the information we need from the Department of Agriculture, from the agricultural college and the experiment station?"

Let the leaders in the farmers' institutes answer these last questions with an emphatic affirmative, and the work is well begun, and when thus begun is half done.

Two years ago there were whole counties of teachers in the State of Illinois no one of whom had ever seen the nodules on the roots of clover; no one of whom knew what they were for, or had ever heard of them. The words protein, carbohydrates, phosphoric acid, hygroscopic, balanced ration, etc., were not in their vocabulary. But this is not true to-day, thanks to the work of men from our college and station in the combined farmers and teachers' institutes and to the cooperation of our county superintendents of schools in this great work of agricultural instruction.

Last winter it was my privilege to address many audiences at county farmers' institutes composed of more than 50 per cent of the teachers of the county and less than 2 per cent of the farmers. There will be many such meetings during the current institute season. Last Friday evening 1,500 people, including 200 teachers and a less number of farmers, assembled in the opera house in Centralia, Ill., to listen to a discussion of the relation of the school work to the life work. It was one session of the Marion County Farmers' Institute, which was attended during the day as well as the evening by the county superintendent of schools and nearly every teacher in the county.

Last Tuesday the court-house at Mount Carmel, Ill., was filled with an audience made up of teachers, some of their older pupils, and a few of the leading farmers. At one of the sessions the county superintendent of schools presided, and steps were taken to organize a boys' experiment club and to interest the teachers in the bulletins from the Department of Agriculture and in the work of the experiment station at Urbana.

In one institute attended by the speaker last week there were 60 farmers and 1 teacher. The farmers were attentive, asked many questions, and took some part in the discussions. On the whole, it was a profitable institute, but for every farmer in attendance there were at least 99 at home. Had the schools been dismissed for the day, as they were in Marion County, and the 100 teachers from the county, accompanied by their older pupils, attended this meeting, scarce a farmer in the county but would have heard something of the institute, the experiment station, and the agricultural college. Moreover, every ambitious teacher present would have carried something of value back to her school and to her pupils, and the dissemination product would at least have been multiplied by ten.

The common schools are one of the educational agencies that we can ill afford to neglect. It is through these that we may most quickly and effectively lay mains to the great reservoir of agricultural knowledge, of which Professor Hamilton has sometimes spoken. It is through such effort as this that we may promote the cause of education for useful activity. It is well to help the graybeards; it is necessary to help the children, too. About the best thing, almost the only thing, the institute can do for the farmers of to-day is to get them on the right side in this educational discussion. For the sake of the next generation, more even than for their own sake, their approval of the experiment station, the college of agriculture, and the teaching of agriculture in the common schools is necessary.

In a few instances we are met with the assertion that such procedure is narrowing in its effects. There are yet a few who oppose what they term "early specialization" in the educative process. They plead for what they are pleased to call "a liberal education" as a foundation for the economic and special education; but what is a liberal education? I answer, it is the education that makes a man free, that emancipates him not only from the bondage of ignorance, but from the bondage of dependence upon other people for his bread and butter, from a parasitic livelihood; that gives him the power to earn his own living—really earn it—by doing something that needs to be done, and thereby contribute something to the general uplift of the race.

What is a liberal education? Let the head of Columbia University tell you what it is not. He says: "The designation 'liberal' has come to be claimed as the sole prerogative of a very narrow and technical course of study that was invented for a very narrow and technical purpose and that has been very imperfectly liberalized in the intervening centuries."

That education is the best, the most liberal in the best sense of the term, for your boy or for mine, that will make him worth the most to the world, able to contribute in the largest possible degree (for him) to human well-being.

It is as certain as the law of gravitation that he who has the most to give, and gives it, gets the most out of life. It is through one's vocation that he makes the greater part of his contribution to human good. Hence, the thoughts of boys should be early turned toward some honorable occupation. "Blessed is the boy," says Jenkin Lloyd Jones, "who comes early to a life purpose, who knows what he wants to do."

The superintendent of the Boston schools has recently said that one purpose of manual training in the schools is to help the boy to be fortunate in the choice of his occupation. This is one purpose of agriculture in the public schools. It is best that nearly one-half of the boys in the schools, probably more than half of those in the rural schools, should select agriculture as a life vocation, and having selected it, should be given the widest possible opportunity to fit themselves for this honorable employment.

The farmers' institute, by seeking the cooperation of teachers and school officers, can become an important factor in giving character to the new education, the aim of which is not "culture for culture's sake," not "art for art's sake," not philosophic leisure, but success through useful activity, through large contribution to human needs, through personal effort in doing a share of the world's work. "Let him who would be greatest among you be your servant." "Happiness through work," says Baker, "is the new creed of the dawning century."

G. A. Putnam, of Ontario, Canada, presented the following paper on the same subject:

The previous speaker has dealt with this subject in a very broad and scholarly manner, and what few remarks I have to offer will be of a practical nature, indicating what we are doing to keep our agricultural educational forces in close touch with each other. The relation of the institutes to the press and the schools will be dealt with in other papers and in discussion.

Cooperation itself is one of the most important questions, not only in its relation to agriculture but to the great manufacturing and producing establishments of the United States and Canada. It is cooperation that has done so much for the agriculture of Denmark and some of the other European and Australasian countries, and it occurs to me that it is to cooperation—cooperation in its true sense, each working with the other for the benefit of all, and not "making the other fellow work," or what has occasionally been the result in our country, "working the other fellow"—that we must look on this side of the Atlantic for progress in the agriculture of the future.

However, it is not of cooperation in its application to the various agricultural pursuits of the country that I am to speak, but of the cooperation of the institute system with other educational agencies. I must admit that the thought which came to me when this subject first received my attention was that it would first be necessary to decide whether you could have a farmers' institute separate from other educational agencies, or whether the institute is not in its nature the very essence of a blending and sifting of scientific investigation, of experimental work, and practical experience—the very life of an institute consists in the educational agencies which go to make it up. If we take these away we have not even the skeleton of a successful institute.

It devolves upon me, therefore, in speaking to this subject, to tell of the various educational agencies which combine to perfect the work of the institute, and in doing this you will excuse a frequent reference to my own country and its institutions. It is probably unnecessary, however, for me to ask your indulgence in this respect, for the history of institutes in any one State or Province is very similar to that in other States and Provinces. We have, sir, in our Province a number of educational agencies which have combined to make, through the medium of the farmers' institutes, agricultural education what we find it in Ontario to-day. And some of these agencies can well be used to still further advance the interest of the agriculturists. Allow me to briefly state what has been and is being done.

(1) The institute system must be in close touch with the agricultural college and experiment stations of the State or Province. There are at least three ways in which this relationship can be established and maintained.

(*a*) The staff of the college and station were first used as institute lecturers. In fact this is the only source from which institute lecturers were obtained in the early history of the institutes of the Province of Ontario; and I am safe in stating that our agricultural college would not to-day have grown to nearly its present proportions or have attained its present degree of efficiency had not the professors and heads of the various departments engaged in institute work some twenty years ago. On the other hand the institutes would not have attained their present position in the Province had not these men been competent, sympathetic, and hard working. Many an ex-student of the agricultural college when asked what first drew his attention to the college will reply that the lecture delivered by some member of the college staff at an institute meeting first opened to him the benefits and pleasures of a course at the provincial institution. It was these lecturers who first brought the college prominently before the people and resulted in an increased attendance of students who were deeply interested in agriculture because they know what it meant to be practical agriculturists, and not because they had a fancy that they would like to be farmers.

(*b*) As the years progressed the professors at the college found it impossible to attend all the meetings that were asked for, so a number of farmers who had become prominent because of their success in agricultural pursuits were enlisted in the work, and at present the majority of the institute staff consists of those men who have made a success in one or more lines of practical agriculture. These institute lecturers keep in close touch with the college and experiment station, not only by reading the literature sent out from time to time, and by coming in personal contact with the professors and those in charge of the teaching and experimental work, but by occasional visits to the college in order that they may see for themselves what is being done in the different departments. The assistance given the institute lecturers by the professors is very much appreciated, and the benefit is mutual.

(*c*) Another source of strength and benefit to the institute members throughout the Province is the literature sent out from the college through the Provincial department of agriculture. The institute members (over 22,000) receive these bulletins and the annual report and depend upon them for direction in the selection of grain, methods of cultivation, classes and types of stock to raise, etc.

(2) The institutes must be in close touch with all organizations formed for the purpose of furthering some line of agriculture. We have the different live-stock associations (cattle, sheep, swine, horse breeders, etc.), the Fruit Growers' Association, Dairymen's Association, Bee Keepers' Association, Poultry Keepers' Association, etc. It would be impossible for me to even briefly mention the work which is being done by these different organizations and how their work is being brought to the public notice and extended through the medium of the farmers' institutes. Allow me to give two instances which will serve to indicate how these different organizations are utilized by the institutes and how the institutes are used to further the interests of the separate organizations.

(*a*) *Dairymen's associations.*—The dairymen's associations, of which we have two, are composed of persons interested in this line of agriculture from all sections of the country. They appoint their board of directors, who are prominent in their own localities, and this board of directors plans certain work for the year, such as the holding of district meetings for the benefit of producers of milk and makers and proprietors of factories and creameries. They also hold an annual convention, to which prominent dairymen are invited and specialists in various lines give addresses. You will ask, "What has this to do with farmers' institutes?" In making arrangements for the district meetings just mentioned the institute officers and representatives of the dairymen's associations are asked to cooperate in planning for and holding the meetings. The officers of the Fruit Growers' Association cooperate with the institute officers in holding special meetings in fruit districts. In those districts where prominence is not given to any particular line of agriculture the institute officers give special prominence to the two or three lines which are of most interest. In this way we are able, through the cooperation of the institute officers and those of the various associations, to plan our work so that all classes may receive benefit. This is a feature of the work which has not been brought to the degree of efficiency which we hope to see in the near future.

(*b*) *Agricultural societies.*—Then, again, we have agricultural societies established in every county of the Dominion, some counties holding from one to eight exhibitions in the fall of the year. These societies are independent of the institutes so far as organization is concerned, but in many of the more progressive counties the institutes utilize the societies and the societies the institutes. This is true cooperation—each doing what he can to further the interests of the other for the benefit of all. As an example: In one county we have four township agricultural societies. At the annual meeting of the farmers' institute an effort is made to elect the secretary and president of each agricultural society as a director of the institute. When the fall fairs are held the institute usually arranges to take charge of some educationa. feature in connection therewith, such as the holding of a live-stock judging competition, an exhibition of grains, grasses, weeds, etc. Then, again, if the institute wishes to hold a seed fair in the spring of the year, or a judging class sometime during the winter, at one of the points where an agricultural society is established, they are strengthened by the cooperation of the president and secretary of the local society.

(*c*) *The winter fair.*—One of the prominent features in educational and live-stock lines is the winter fairs, held at Guelph and Ottawa. At these fairs valuable prizes are offered for nearly all classes of live stock, and advantage is taken of the large exhibits of first-class types of the different breeds and classes to utilize them for illustrating lectures and addresses by men who are prominent in the raising, feeding, curing, marketing, etc., of these products. The meeting of institute lecturers at the winter fair corresponds somewhat with the "round-up" which is held in many of your States.

The aim of the department is to so arrange the field educational work that the institute officers will be composed of representatives from all societies which have members in the district. Then each of these phases of agriculture will receive its due proportion of attention at the regular meetings, and the members of the various societies will have an opportunity of lending their assistance to the institute officers to further the special meeting in which they are interested.

We are of opinion that the educational work in each district should be undertaken through the institutes, while the experimental work done in different sections of the Province should be undertaken by the various societies. The institutes should keep in close touch with this work (the work of the societies) and be prepared to distribute information by lectures and literature where they will be of benefit.

W. C. LATTA, of Indiana. When the institute work began in Indiana it was at a time when certain farmers and organizations had been springing up, and the question now arose, "Is this some secret organization you are developing?" and I soon found that the people were looking upon it with suspicious eyes and questioning about it; and it was borne in upon me then, at the very outset, that this work must be one of cooperation. We have not made the progress that we ought to have made in our State, but we have made some. Along one line we are attempting cooperation, namely, with the schoolmen. Friends, I am no longer sanguine of doing very much good in giving instructions to adult people. Our definite objective point is the boy and girl in the schools, and so we want to interest the schoolmen in the work and bring them together. At the last two annual conferences—the one held last October and the one held this last month—we brought the schoolmen there.

We had Mr. Kern, of Illinois, who is a power in that line, and we had our own superintendent of public instruction, and we had a county superintendent in our State who has been doing a great work in getting the boys interested in corn growing. This subject is so wide and comprehensive that the workers are necessarily separated when working each in his own line, and there is danger of a feeling of isolation, so that there is need of bringing the workers together. We hope to accomplish much on that line.

This subject is one that must receive increasing attention, and we must get in closer touch with the teachers of these rural schools if we are going to accomplish the greatest good in the future.

Thereupon, at 10.20 o'clock p. m., the association adjourned until November 11, 1905, at 8.30 o'clock a. m.

MORNING SESSION, SATURDAY, NOVEMBER 11, 1905.

The association met at 8.30 o'clock a. m., the vice-president, E. A. Burnett, in the chair.

John Hamilton, Washington, D. C., Farmers' Institute Specialist, presented the following paper:

MOVABLE SCHOOLS OF AGRICULTURE.

The farmer's institute, as at present organized, has its limitations. In some of the States in which the institutes have been longest in operation there are already evidences of their having about reached this limitation, and unless their work is broadened to meet the advancing needs of farming people in the science of agriculture they will eventually cease to be an important factor in rural education.

INSTITUTE ORGANIZATION.

The farmers' institute of to-day in its organization and methods is essentially the same as it was fifteen or twenty years ago. It consists in meetings of farmers, called for the purpose of giving and receiving information in agriculture. The meetings usually continue from one to three days with a tendency toward the one-day institute. The instruction is given by lectures followed by questions and answers. At a two-day institute it is not unusual for the programme to include from ten to fifteen separate topics presented by from three to as many as ten or twelve speakers.

In these respects the institute is practically unchanged. Such improvements as have been made have been in the way of arranging for meetings and appointing speakers often months in advance of the institute season, and in the discarding of sensational exhibitions and incapable men as lecturers and substituting for them those who are experts and authorities upon the subjects that they present. In these respects there has been great advance.

ADVANCE IN RURAL INTELLIGENCE.

In the past twenty years country people have not been standing still. The instruction that the institutes have given and the improvement in agricultural journals, which circulate more widely and are read more intelligently and generally than ever before; the distribution of bulletins of information by the agricultural experiment stations and the State and National departments of agriculture, together with the work of the agricultural colleges in educating young men and women and sending them out in increasing numbers to follow agriculture as a profession, have all had a wonderful effect in increasing the intelligence of country people in agricultural affairs, making it more difficult each year to provide instruction of a kind that will satisfy their intellectual and practical needs.

SPECIFIC INSTRUCTION NEEDED.

The more progressive farmers are not now desirous for variety in subjects so much as for more exact and specific instruction, teaching that will show precisely how an operation is conducted and how the science of it may be applied in ordinary practice and under the average conditions by which farmers are surrounded.

Right here is where the present system seems to fail. The small amount of time devoted to any topic is such as to make it impossible for the teacher to do much more than introduce it. The field of agricultural information has been enlarged to such an extent that no man in an hour, a day, or a week can at all exhaust one of its more important subjects. Indeed, in the schools it is now found to be necessary to take several weeks of careful study and drill to become acquainted with such a subject as butter making, or cheese making, or fruit growing, or market gardening. More time to a topic is the need.

The farmer now wants to know all that has been discovered about a subject, and he wants the information systematized so that he can use it in his business. He has discovered that a little agricultural learning is dangerous in that it is often an expensive thing. He has learned that half knowledge is apt to mislead and injure rather than direct to profitable results. More extended and specific instruction is the need of agriculture, and if the institute is to continue serviceable it must provide it.

SMALL CLASSES.

The study of special subjects for any considerable length of time must necessarily be confined to small classes. Large and promiscuous audiences can not be expected to devote two or three weeks to the consideration of any topic, neither are all interested alike in any one subject. Dairymen are not specially interested in fruit culture, nor the fruit grower in dairying. This necessitates the formation of classes composed of persons interested in certain specialties—interested to the extent of being willing to devote sufficient time to the study of a subject to become fairly well acquainted with its most important scientific and practical features.

MOVABLE SCHOOLS.

To meet the new conditions and needs, the movable school of agriculture has been devised. Such schools have, in foreign countries, largely taken the place of the old-time farmers' institute. The method is for the State director or superintendent of institutes to arrange for the formation, in various districts or centers, of classes numbering not less than eight nor more than fifteen persons who agree to attend upon a course of lectures upon a single topic and to participate in such practice work as the course prescribes. The teaching force consists of one or at most of two instructors who are experts in the subject they present.

If the subject be cheese making, for instance, the course would begin with the study of the character and composition of milk and continue in logical order to the completed product, the students participating in the various operations, so as to be able upon the completion of the course to do the things that they have been taught.

The equipment of apparatus for giving instruction would be provided by the State directors, and the hall, with its heating, lighting, and janitor service, together with water for cleansing utensils and fuel for heating milk, etc., to be furnished free of charge by the class, together with the milk necessary for demonstration and practical purposes, the product to be the property of the donors.

By this method schools on a great variety of farm topics could be organized, limited in number and variety only by the money which the State director has at his disposal.

EDUCATE SPECIALISTS.

Through this instrumentality it would be possible to educate in one or more specialties ten or twelve persons in each community who would be well fitted for conducting special lines of work and become eventually experts and sources of information and aid to others.

The expense of such a school would be the salary and traveling expenses of a competent instructor and the cost of the equipment of apparatus and material necessary for demonstration and practical work.

The teaching would not exceed an hour a day for the lecture, and one and a half to two hours for practical or laboratory work. The instructor in the intervening time would be expected to visit some member of the class each day at his home, and give such special assistance and advice as would enable the pupil to utilize his home equipment to the best advantage for pursuing the line of work that the school was organized to aid.

COURSES OF STUDY.

In order that the State directors and institute instructors may have a guide in undertaking this new feature of their work, the Office of Experiment Stations of the

Department of Agriculture has undertaken to prepare and publish for distribution courses of study upon cheese making, butter making, poultry rearing, and fruit growing, with lists of references to authorities, items of apparatus needed, and detailed outlines of practical work.

The introduction of such a set of courses in a State as supplemental to the present method of institute work will round out the institute system, provide for its indefinite extension, and furnish employment to skilled teachers through the entire year.

O. C. GREGG, of Minnesota. In the first place, I like the thought. Again, I agree with what my friend from Illinois said last night, that the institute as now organized is a place in which we excite interest and enthusiasm. I have come down to that in my institute work in Minnesota, and I find that it is a successful thing. On the other hand, I fully appreciate the fact that we can not make the institute a school, in giving details. That is why we put $5,000 out of $18,000 into an Annual. Get people thoroughly aroused and they will read the book. But the book is not a live teacher.

You can not hold a large crowd on one topic. We have a man talk a short time on each subject. We are going to make in every county a central point where we can have these things, and if my vote counts for anything, Minnesota is going to start that.

ANDREW ELLIOTT, of Ontario. I am happy to find that Mr. Hamilton thinks the time has arrived for movable schools. This is a movement in exactly the right line. It is true enough that we can not dispense with the old system of farmers' institute work for the young people growing up, but we must go a little bit farther ahead, and we must no longer be content with telling people how to do a thing; but we must also tell them why it has to be done, and then we have them on a thinking basis, and it is the lack of thought that is the greatest drawback we meet in the agricultural community.

The CHAIRMAN. Ontario has had a movable school in a little different form—a dairy school. How long did they stay in one place?

G. A. PUTNAM, of Ontario. We have not had what you might call movable schools in Ontario, but we have had the traveling dairy. That was started some fifteen years ago. The method in that was for an advance agent, as I might call him, to travel from place to place throughout the dairy section, and consult with prominent dairymen in the different districts, and arrange with them for a suitable place in which a dairy meeting could be held. This advance agent made provision for the supply of cream and a suitable place for the churning demonstration to be held, and in many places a lecture was given in the meeting in addition to the demonstration. I had almost forgotten about this, it is so many years ago. But this same thing is now being carried on in the Province of Nova Scotia. Miss Rose, one of our workers, in the winter months, spent some time in Nova Scotia, and she has had most successful meetings. She held a series of meetings, with four sessions, two sessions each day, for two days in a place, this summer, with an average attendance of 64 at the meetings.

Four or five of the lady delegates who went from Province to Province attending institute meetings during the past summer mentioned to me that they never came across poorer samples of butter than in the hotels where they were. We attribute the success of our butter makers in Ontario to the work of these schools I have mentioned.

O. C. GREGG. This matter of the traveling dairy was introduced into our institute work through Professor Carlisle, who is now in Colorado, and the commission men said that right there began the revolution in butter making in Minnesota.

G. C. CREELMAN, of Ontario. It seems to me this is pretty well summed up. You may call it a movable school, or call it bringing the live stock out to the meetings; you may call it getting a special car and running through the country; you can call it putting a churn on a wagon and going from point to point giving demonstrations of dairying, or whatever you please; but the fact remains that the people at the present time living on the farms learn to do things, not by reading or listening to talks, but by seeing them done, and then doing them themselves. In the early days, when the institutes started, anybody was employed that could be gotten hold of, anybody that could talk well, theoretically or about practical things. That condition has passed away. Then came the man with the charts, and, as Mr. Kydd says, he pointed to the different parts of the horse, and said this and that ought to be thus and so. That phase of instruction passed away, and now we have the horse himself used in demonstrations. Now we have come to the point where we have to demonstrate things practically. As I say, you can call this work anything you please. But the time has come when we have to quit this pioneer work that has been done and get things in shape at the meetings to demonstrate the work.

F. H. Rankin, of Illinois, presented the following paper:

BOYS' AND GIRLS' INSTITUTES.

Every department of human endeavor is pulsating with progressive activity. There is a smaller sphere for the uneducated man of every decade and a diminishing possibility of success for the man who does not read and think. The reading man is in the saddle; the thinkng man is guiding the nation's destinies.

At no period of history has the intellectual thought of the agricultural classes been stirred as it is to-day, and therefore we see springing up on every side these agencies which are at work to stir the farmer out of his intellectual apathy. The farmers' institute has won for itself a leading place among the several educational influences that are working for the benefit of the farmer. It stands in close touch with the people of the agricultural colleges and experiment stations on the one hand, and seeks to bring the farmer to a better acquaintance with them on the other. In short, the spirit which it imparts to this work is to make agriculture not only the support of man's body, but also an inspiration to his intellect. The key to improving agriculture in any place in the world is its intellectualization.

The farmers' institute work is an effective agency for disseminating knowledge of use to agriculture which scientific men are discovering, and it gives the opportunity for the dissemination and exchange of ideas among the farmers themselves for information in regard to their occupation. The farmers' institute is a distributing agent; this is its mission. The most successful and acceptable men upon the lecture force are those persons who have themselves had the experience and know the value of the truths that they teach. The information which they bring, to be of service to those to whom it is given, must have been tested and used and applied until its value and practical character have been clearly shown. No common or ill-equipped instructor should have a place in this work. The speaker at the institute should be a man who knows at least one thing well and can vouch for its truth; who has seen it tested and is willing to stake his reputation upon the accuracy and reliability of the statement which he presents. I believe that every institute superintendent will bear me out in the statement that the greatest difficulty which confronts him is to find a sufficient number of men of the character described with which to provide material for the institute lecture force.

At meetings of this character we hear a great deal about the selection of speakers for institute work. But there is another question beyond that. After we have gotten the speakers how shall they be trained and developed?

It seems to me that our agricultural colleges are not yet working up to their limit, so to speak, along this line. There is yet a work which but few of them have ever attempted. I do not believe that our colleges will do their full duty toward institute work until they have provided some special training for the young men enrolled in their schools to fit them for this institute work. I do not refer simply to the training of them in agriculture and the varied sciences connected therewith. I mean giving them something of the practical teachers' training, so that they can take the knowledge they have and stand up before their fellow-men and present it in a clear, attractive, and convincing manner.

There is something along this line in which our agricultural training needs a little more developing in the way of assisting these young men in qualifying themselves not simply as speakers at meetings, but as teachers and leaders in our institute work. In the speaker's opinion this should not be left to the somewhat uncertain help or assistance obtained at the literary society or debating club.

Recognizing the importance of this work, the Illinois College of Agriculture, two years ago, introduced a regular course of study which is termed "farmers' institute management." This course is the study of the farmers' institute as a factor of our public education. It is designed to set forth the principles applied to the organization and conduct of farmers' institutes and agricultural associations; to systematize into definite lines the knowledge acquired by the students in the college to the end that they may render more distinctive service, upon their return home, in the institute work of their counties and State; and also to inspire within them the desire to become active members of some of the agricultural associations of the State. Lectures, assigned readings, parliamentary practice, the making out and advertising of institute programmes, etc., are leading features of this course. More than 50 young men have taken the work each year.

It is not our aim in this course to pound a lot of knowledge into a boy which may or may not be of any practical use to him afterwards, but rather to fill him with a boundless enthusiasm and set before him high ideals, intellectual and moral, and thus equipped the young farmer takes his place among other citizens as a public-spirited man.

The speaker takes the stand that the very best representative men should be found upon the farms of our country; but so long as they neglect to secure broad, liberal education, just so long must they be relegated to a back seat. The training which a boy gets—if of the right kind—during his school days, followed by active participation in farmers' institutes and kindred associations, will give him the equipment necessary to use these opportunities to the very best advantage. It will encourage and develop the gift of public speaking, and the ability to preside at any public gathering with ease and dignity. These gifts must be used by some one in every community, and happy is that man called upon to play his part who has during his younger days prepared himself to do so with ease to himself and satisfaction to his neighbors.

The course in farmers' institute management offered at the College of Agriculture of the University of Illinois affords the very best opportunity possible to cultivate these gifts and gives the young man definiteness of purpose. A decided mind is a tower of strength in any man's life, and in a general way stands for success. To know the right course, and to be sure that you know it, gives steadiness and accuracy of work.

While, so far, I may not have adhered very closely to the topic assigned me, viz, "Boys' and girls' institutes," let me hook to it the other end first and consider institutes for girls and boys.

The ideal or perfect institute must have good learners as well as good teachers. It must develop and strengthen the idea of self-help. This idea of self-help has been prominent in Illinois farmers' institutes from the first. Our local men must and do work up the local institute. Whenever you get a local man interested and enthused to act and work, there follows the death of "his institute" or "your institute," but there rules instead the broader conception of its being "our institute," and all feel that they are not only welcome but a part of it and responsible for its success.

Much depends upon the parents of the young people. The most difficult institute to arouse interest and enthusiasm in is the one composed wholly of old, gray-haired men, numbering many "retired" farmers. Do not misunderstand me as being disrespectful to these older members of the farming community. They are all right and needed in the institute, but they should not be there to the exclusion of the boys and girls. There is something radically wrong with the institute management which needs reconstruction if there are no young people in attendance. In every community there are boys and girls who can both entertain and instruct an audience. Urge them to take up and discuss some question of common interest to the locality. Secure a young lady, or several of them, to favor the audience with a piece of music at opportune times. These young people who consent to take part in the meeting themselves will generally bring a number of young people from their neighborhood to the institute. Short recitations, requiring but a few minutes' delivery, from a boy or girl will not only please and stimulate the young people, but will often win the parents who might otherwise not be in attendance. They will feel a pardonable pride in knowing that their son or daughter will speak at the institute. And, again, any well-organized institute could add to its usefulness by offering "awards" or "honors" for special proficiency in farming. It is but little trouble to secure premiums among the farmers themselves or the business men of the town in which the institute is to be held. And supplementary to the prizes, honorable mention could be made for excellence of work; classification could be made as to the best-kept farm; the best arrangement of farm buildings; the best acre of corn or potatoes or other crops; the best garden; the best-kept house yard or grounds about the house; the best yield of eggs; the best butter. Also premiums may be given on culinary products, corn, etc. I am of the opinion that a decided influence would thereby be given to the institute and consequently to agricultural progress. Plans can be made ahead for these features and inexpensive tokens of merit may be awarded at the institute session at which the report of the successful competitor should be made. These are some of the helpful features for creating a more active interest in the institute.

Many of the counties of Illinois have organized what are termed boys' experimental clubs and girls' home-culture clubs. To illustrate: Winnebago County has a farmer boys' experimental club with more than 500 members, and a girls' home-culture club with more than 300 members. The boys there are growing a high-bred variety of corn, and also sugar beets for a beet-sugar factory. This year 112 boys planted corn from seed furnished by the officers of the Winnebago County Farmers' Institute. Some 75 members of the club volunteered to grow sugar beets. Over 50 acres were planted by these boys. This work is in cooperation with the Winnebago County Farmers' Institute, the officers of which offered the following prizes to the boys in last year's corn contest, all premiums being cash: First prize, $15; second prize, $10; third prize, $5; fourth prize, $3; next ten prizes (each), $1.50; next ten prizes (each), $1.

All other boys making exhibits would receive cash premiums at the discretion of the corn committee. The boys who take first, second, and third premiums are expected to write an article, to be presented at the institute, telling of the preparation of the seed bed, planting, cultivation, and harvesting of their prize corn. Let me remark in passing that it is a hopeful sign for the farmers themselves to believe enough in their own boys to contribute cash for prizes without asking the merchants of the town to donate collar buttons, link cuff buttons, suspenders, stock food, etc., to encourage the farmer boys to be better farmers.

The following are a few of the prizes offered to the girls of the home-culture club:

For sewing, patching, darning, prizes in each of these: First prize, $1; second prize, 50 cents.

Six prizes were offered for the work of girls of 12 years of age and younger and six for that of girls 18 years of age and younger. The following classes were made:

First and second prizes for handkerchiefs made by hand; first and second prizes for best setting in of patch in piece of plaid goods. First and second prizes for best darned hole in dress goods or table linen not less than 1 inch in diameter. Prizes were also offered the girls in bread-making contests. This is to cite briefly from Winnebago County, which is only one of the many counties which are taking up the same line of work.

However, they have gone a step further than this. It sometimes develops that the boys were there more for the premiums than anything else, and, after a year or two, while the boys bring in better corn both as regards quality and selection, they sometimes pattern after older exhibitors and bring in corn which they did not raise and got help from others in the selection of the same; and thus the exhibit degenerates into too much of a scramble after premiums; for the boys and girls often made an exhibit when they had nothing to do with the growing or selection of the corn.

This year the Illinois Farmers' Institute has inaugurated a new kind of a contest known as the "corn-judging contest," one in which the boys would get the benefit of the contest themselves. Mr. A. P. Grout, treasurer of the Illinois Farmers' Institute, last year offered as a premium to pay the expenses of the winner of this contest while taking two weeks' instruction in corn judging at the college of agriculture. A competent corn judge and instructor were provided. The first day of the meeting the boys were given careful instruction in corn judging, and they handled the corn, measured, and scored it. This school was conducted both forenoon and afternoon. The next day the boys were examined in corn judging. Nineteen boys competed and did good work. And, by the way, this instruction was worth just as much to the older people back in the audience as to the boys. The parents of the winner of the prize in the first contest wrote a letter to Mr. Grout thanking him and saying that "their boy was so much pleased that he now wishes to take a full course, thinking it the only course for the coming farmer boy."

Several counties are planning to introduce this corn-judging contest into their institutes this year. One county is offering premiums of this kind to boys of each township in the county—as many premiums as townships. Who can measure the educative results of sending a boy from each township in a county to the agricultural college for two weeks? It means the facing of so many boys, perhaps for all their lives, toward scientific agriculture. It means the telling of the story of their trip and the instruction received in detail to their parents and schoolmates. It means the interesting of scores of other boys and their fathers in the practical training in agricultural lines and the marvelous achievements of the college of agriculture and experiment station. Every step in such a contest is an education to the boy, whether he wins the large prize or not, for one of the conditions is that the contestants must attend the day sessions of the institute.

The boys and girls go into these contests with vim and enthusiasm, and who will gainsay that these experimental clubs as fostered by the State farmers' institute and the agricultural college are valuable accessories of the farmers' institute work? We believe that the true effort which this work creates will make these boys better men. These boys want to be made wiser to-day than they were yesterday, and I have a lively faith that observation and reflection, thought and study, are just as essential in the great business of farming and farmers' institute work as in any other pursuit. The purpose of an institute which does not have in mind the striving for higher ideals in youth needs reconstruction.

There are many ways of getting the boys and girls interested in an institute besides those indicated, such as getting the boys and girls together during the recess period and having a little class in corn judging, or explaining some of the commercial products of the corn plant or the root development of the clover plant or soy bean, a sample of which is easily carried in a sealed can. Encourage some of the boys to bring some live stock to the place of meeting and have an expert there, some person from the agricultural college or a competent stockman. Conduct a class in stock judging. Pigs, sheep, cows, horses, etc., should be taken as object lessons, and the good points and defective points indicated. In conducting a class, or exhibit in judging, the reasons should be given, explanations made, and questions answered on all points thus considered. Questions relative to the most desirable types and good qualities of animals can thus be more intelligently answered with the specimens actually before the young people.

Following such a session, while interest is keen and their entire attention is given, is the time to ask a few questions and drop a few suggestions as regards the agricultural college. Make suggestions along the following lines: Why not have the best herd of improved stock? Why not increase the fertility of your land and command your neighbors' respect by having the neatest and tidiest kept farm? Suggest that experience is a dear school; that they are soon to face the problem of self-support. Ask them if they understand how to correct the defects in the soil; to reduce the ravages of insects and plant and animal diseases; how to get rid of undesirable tendencies in flock and herd. If they wish to learn the secret of a larger success in these and other lines, there is no better place to spend a short time than at the college of agriculture and experiment station where many up-to-date ideas come from. Point out in detail the courses the agricultural college offers to students which are designed to fit them for the business of farming and at the same time to furnish a means of culture. The latch string hangs out, and such an education is within the reach of every boy, provided he wants it and makes up his mind to that end. In this way the mind of the young people can be led up to the most important feature of the institute work. I want to drop this word in passing: There is no interest I know of that is at all comparable with live stock as a means of interesting and educating and entertaining the young people. You all know how it is when you go and buy a pure-bred mare, cow, hog, sheep, how the boys will immediately become interested. They are comparing the animal with that of their neighbors, or the kind they had before, and as the progeny comes along they are anxious to see it and examine it and decide upon its qualities. They are held; they are interested; there is nothing like it on the farm.

After all, the greatest live stock, the most valuable live stock, are the people—the boys and girls who live on the farm and for whom these institutes are really conducted, for the older ones are "sot" in their ways and must ere long pass from the active stage of life. After all, what makes the land worth anything is the people who live upon it. This land of ours was not worth anything until there was some kind of people on it—not worth anything. But when we have a great farming population of intelligent men and women; now that it is well stocked with people, America is the greatest country in the world. After all, it is the people who make it.

Ladies and gentlemen, if we were privileged to return to our childhood days would we not, with the knowledge which the years have brought, give a more certain trend to the acts of that period? Yet in this institute work there comes the opportunity to place yourself beside this latter-day child, the farm boy, and make yourself, as it were, a child with him and lead him to that higher plane of which true manhood is the summit.

In brief, the farmers' institute conducted for boys and girls will develop in these young people manhood and womanhood, will broaden their views, enable them to separate the good from the bad, develop in them an inquiring mind, and tend to show them the real privileges of true citizenship.

These potent influences are factors in directing the lines of the lives of these young people, which are as true as the needle to the pole, and will help the farm boy to become a modest, thoughtful, studious, public-spirited man, well fitted to pursue his chosen calling and, if circumstances demand it, to grace the halls of any legislature.

While the institute worker may be building for a permanent as well as for a profitable agriculture, remember there is yet another class of results which perchance are not always in your plans, the history record of which can not be written; it is that unconscious, unrecorded, unintentioned influence which in a good man's life often aggregates more in the end than purposed acts.

A refreshing enthusiasm, assiduous energy, optimistic leadership, exquisite urbanity, and personal loyalty to right principles are assets which may be accumulated and which may make a life an exemplification of Doctor Johnson's motto: "'Tis better to live rich than to die rich."

W. L. Amoss, of Maryland, presented the following paper:

COOPERATION WITH THE NATIONAL DEPARTMENT OF AGRICULTURE.

From the farm, the farmers' club, the farmers' convention secretary I came to be a farmers' institute director to administer a bill which had been drafted by a club of farmers, which read: "The purpose of these institutes shall be to bring before the farmers of the State such information as will effectively remedy many of the existing evils now prevalent in every department of agriculture as now pursued in Maryland."

As secretary to the farmers' convention, the first duty assigned me was to find a man who could tell our road commissioners and our farmers how he had built a permanent road. This was eighteen years ago.

Nine years after in the institute work I found that my department could only grow through the use of men from the farm—what you understand to be practical men. When I called upon the experiment station, the man who did the best and most approved work brought information how he had grown products on "his" farm, and at the experiment stations I was fortunate in my search for practical men in having an acquaintance that introduced me to George T. Powell, of Ghent, N. Y., a practical man, a student, and one in close touch with the work of his experiment stations. Through him I met another practical man, Edward Van Alstyne, of Kinderhook, N. Y., also a student of agricultural literature. These men, and others of their type, with the good sound advice gotten at the meetings of this association, have built up a patronage to my department of which I am proud.

Soon after I began drawing on that excellent force of workers of Mr. Dawley's they began their annual meetings at their experiment stations. This was close on to ten years ago. There has been a great change in what the stations had and what the stations have, in both men and facts. The best institute workers come before the audiences to tell how they have succeeded and how the experiment station has succeeded in doing work. As I see the trail of progress for us, as institute directors, it is to take out to our farmers what the experiment stations have done through men who themselves are doing what they have gleaned from the bulletins of our experiment stations.

There is a place on our programme for the specialist—I am not at war with him.

Now we come to what the National Department of Agriculture can do to help the farmers' institutes. This great Department is the greatest of all experiment stations. What we have done for the State experiment stations we can do for the Department of Agriculture. What the experiment station has done for the institute the Department can do for the institute, and do it in the same way. Its methods of helping will be subject to change and improvement as have the methods of the experiment stations. The experiment stations found that their literature was not read, that the wastebasket was the file used in many instances in many farmers' homes for the bulletins. To-day the literature of the Department is not on file in the farmers' homes as it should be. Every division of our great Department has gathered and stored away a vast amount of information that needs to go out to the farmers, as we, as institute workers, have taken to the farmers of our respective States the information gleaned from the literature of our experiment stations, excepting, perhaps, it would only be necessary to bring it to the institute director and help his department disseminate the information.

It would be necessary for the institute specialist to have a few men whose work would be to carry this information. As to methods and equipment, I need only to say they should be the same as are now used by our State experiment stations. The Department should train institute workers sent to it on the approval of State directors. A short course should be organized. The Secretary said that he had found it necessary to train his men, that the colleges were not turning them out. Now, we need to have men trained, and I believe the Department of Agriculture can best do this for us. At the same time they can be the carriers of information from the Department to the State institute departments.

The Department of Agriculture can be to the State department of institutes what the State experiment stations have been, and the same methods can be used by it as are now used by the stations, and I believe the Department will be equally benefited by the helping as it has been to the State department experiment stations.

WOMEN'S INSTITUTES.

Miss R. **Blanche Maddock**, of Ontario. We have met this year, as we have done for a number of years past, for the purpose of learning all we could from your organization, in order that we may be better fitted for our own work through our States and Provinces. I believe, however, that the time has come when we should have at least a committee of women to work in connection with the Association of Farmers' Institute Workers, so that we may have either separate sessions or may meet with the association. You may possibly hold your association sessions so far away that it would be impracticable for us to attend them, but we ought at least to keep in touch with the workers from Canada and the United States, so that we may in the future form some plans for definite work, for the improvement of the work both here and there. Owing to the change of the place of meeting having been decided upon at so late a date this year it has been impossible to accomplish anything. It is believed, however, that your work will be helpful to the work intrusted to us as women. The commercial value of your work is not to be estimated. But there is another thought to be considered, and that is that in this country millions of foreigners are crowding to our shores, from all the countries of the Old World, asking for protection and a home. We welcome them, of course, and we hope that in time they will become good American and Canadian citizens; but we also recognize the element of danger there is in this mixing of classes and creeds. Will the result not depend largely in the future on the stamina of the young people whom these strangers meet—the character of the people whom they meet on this side of the water? This is the thought that I should like to present—that you have the commercial side of it, but as women, as mothers and sisters and daughters, we are trying to do our part in making the young citizens so strong and noble that as they come in contact with these farmers it can not help but tell in the unifying of the country and its peoples. It is all very well, of course, to talk about live stock and cultivation, and all the other subjects that are necessary, but there is a thought behind it all, and that is, I believe, that the result will largely depend on the kind of homes we have, and the social and intellectual life that we have in those homes.

I ask the cooperation and sympathy in this work of the State superintendents who are present. It is impossible to send lady delegates to these different association meetings without money, without assistance, and I would ask that this coming year the superintendents should see that some provision is made for sending lady delegates, so that we will have a strong representation next year, so that we may hold sessions with you, or separate sessions, where we may be able to present our work.

INSTITUTE ORGANIZATION AND METHODS.

L. R. **Taft**, of Michigan. In our work in Michigan, and I am sure it is so with you, we find that we still have unsolved the question of the best method of institute organization and the best methods of work. I will not, however, attempt to outline to you what my ideas regarding these things are, because after listening to the reports of the various States as to the various conditions under which you work, I am convinced that no one method would answer for all; but this morning I wish merely to refer you to a paper prepared by Professor Hamilton, in which he gives us a scheme for the organization of our institutes in the different States. (See p. 78.)

This scheme he has prepared is very complete, and, in fact, if I were in any way to criticise it, it is because it is rather too complex for the average State; but I believe it will be very useful to us. It is full of good suggestions, and I think we ought to print this in full in the report of this meeting and have it for reference in the future. He has taken the methods in use in the different States for the past year or two, and has deduced from them what he believes to be the best method of institute organization. He gives not only the constitution for the State, township, and district societies, but it also gives a law that might be enacted in establishing an institute district. I would say that to a very large extent the ideas would meet with my approval, and they would work, I think, in most of the States.

Professor Hamilton advocates first a central supervision, and combines with that the local organizations for the county, township, and district, and he recommends work along these lines to secure stability and perpetuity of the work. You can see the importance of the organization for this purpose. The whole scheme is prepared with the idea of securing the cooperation of the agricultural colleges and experiment stations, and I know that in States where they have quite close connection between the colleges and institute work it gives them good results. He recommends making this a State institution, in order, in the first place, to have appropriations from the State, and to provide for development of the institute system. This scheme as prepared here gives us the outline for a system, and he provides for a central board of control with a director as executive officer; and this governing board, as he recommends, will consist, first, of the president of the board of regents of the university or agricultural college—whatever your board is of—and next the dean of the agricultural college or the president of the agricultural college, the director of experiment stations, the superintendent of public instruction, and also four delegates selected from the county institute society. These directors of institutes would serve without pay, but would have their expenses from the State.

He further provides for the payment of $100, or of a sum to be fixed, of course, from the county treasury, to pay the local expenses of the institutes—increasing, of course, in proportion to the funds.

The secretary of the State board of directors would serve for three years. It also provides for the printing and sending out of the reports of the institutes. As arranged in this scheme, the board of directors would fix the dates for the meetings, review the programmes, and arrange for the speakers. It would also provide for institutes for women, for traveling libraries and reading clubs, and would defray the expenses, except the local expenses. It arranges for an appropriation by the State. The scheme goes on to provide a constitution and by-laws, as I said, for the county, township, and the district, for such societies.

I have thus very briefly outlined what the system is.

It seems to me that it is very desirable that we have something in the way of county organizations, and that we should have in all States a State organization for carrying on the work. Whether we should attempt to modify our present systems and have the board of directors of the States selected according to this plan, or whether we should keep up our present methods, would perhaps be a problem for each to solve for himself. In our own State, although we do not have a State board of directors, it follows along about the same lines as set forth in this plan. Our board of agriculture in Michigan is really the board of trustees of the agricultural college, and the president of the college is a member of that board; so that we follow very closely this plan except that we do not provide for the four delegates from the county institute societies.

It seems to me in many respects this is an admirable idea to bring the institutes closer to the farmers, and to make them feel even more than we can now that these are farmers' institutes. Without taking further time I want to recommend this report as a part of the proceedings of this meeting.

E. E. Kaufman, of North Dakota, presented the following paper on the same subject:

Every State institute director has the problem of methods and organization to deal with, and we find nearly as many different plans followed as we have States.

I suppose nearly every director believes his State has the most nearly ideal system, and really how many of us are in a position to say he has not until we have made a thorough study of his conditions and environments?

What a grand, good plan it would be if a uniform system could be devised and put into effective operation throughout all the States.

Such a system would undoubtedly contain a township organization, a county institute, and a governing board for the State. With such a system working harmoniously and a legislature inclined to be liberal with appropriation the superintendent would have the smoothest kind of sailing.

In some States, I am inclined to think, such a plan could be inaugurated and carried out very successfully. To my mind the conditions for such a system would be found in the older States, where the farms are nearly uniform in size, the country well settled, and the people all, or nearly all, of one nationality.

Opposed to this method of organization is what is generally called the one-man system, although rather incorrectly, I think. By this plan the institute work is generally under the management of a board which secures a superintendent who plans and carries on the work without any organized local societies or clubs. Under such a system is my own State working, and while it must be admitted there are some drawbacks, yet I am inclined to think it is the better plan for the present at least.

With a large alien population of at least six different nationalities more or less suspicious of one another, bonanza farms, and farm houses often miles apart, conditions are none the best to attempt ideal methods until institute work is well on its feet and firmly established. Indeed, I am not sure but what, under the aforesaid conditions, the so-called one-man system would more nearly approach the ideal method of organization.

The greatest objection that can be brought against that method is that of creating sufficient interest locally to make a successful institute. If the superintendent is the right man in the right place he will be able to select a local committee which will give the matters of advertising and arrangement as much time and attention and just as good results will be accomplished as when performed by the officers of a local society.

Where a local society is in existence, the president feels that it is one of his prerogatives to preside during the institute, and resents the action of the conductor in taking charge of and conducting the meeting. To be entirely successful at all times I believe the institute should be conducted by an experienced man. True, that can be provided for in the by-laws of the society, but it will often be the case that the president will desire to exercise his prerogative, and rather than have any trouble the conductor will step aside and waive his right.

For the best results the governing board should not be too large. Five, I believe, is sufficient and seven at the most. Where it is necessary to travel long distances a large board is expensive and at the best unwieldy.

In an organization where the county societies would send delegates to the annual meeting it would cost in North Dakota from $1,200 to $1,500 to pay the expenses of delegates and board members for a year. The question naturally arises, Could not this amount be spent to better advantage in holding a larger number of meetings?

With all due respect to those who favor the township, county, and State organization scheme, I must say that in my opinion such a system would not bring the best results in North Dakota, for the present at least.

With larger appropriations, a larger experience, and a better knowledge on the part of the farmers in the aims and objects of institute work and less rivalry between the different nationalities, conditions will change, and I am not prophet enough to state what would then be the best plan.

In conclusion, I want to state that I am not antagonistic to any system which will bring about the desired results, and that in our work the farmers are urged to organize local clubs and societies. A few such have been formed, some of which have weathered the storm and some have fallen by the wayside.

Results are the thing desired, and the system that will bring results under prevailing conditions is the one to follow.

The paper by John Hamilton referred to by Professor Taft is as follows:

FORM OF ORGANIZATION FOR FARMERS' INSTITUTES.

The early or formative stage of every great movement is usually a period of comparative confusion. Whether it be the development of a science or of a political reform, there is always a time when information is meager, views are more or less vague and conflicting, and methods are correspondingly crude. As information is gathered and better methods are discovered a common understanding is reached, and at length a well-constructed system or organization is effected.

Until quite recently the farmers' institute movement has been passing through its formative period. The institutes were begun by the several States independently of each other, with very little or no experience to guide those in control, and with no central authority or general bureau of information to aid in coordinating their work. The natural consequence has been that wide differences exist in the laws, forms of organization, and methods of management of the institutes in the several States.

Some of the States have laws that are quite elaborate. They prescribe in detail the methods to be followed in conducting the institutes, the number of meetings that shall be held, and the amount of money that may be expended each year. In others they are extremely simple, merely recognizing the institute as a factor in education, and leaving the details of its organization and work to the individual or board intrusted with its management. A considerable number of the States and Territories have no institute legislation whatever. In these the work is dependent upon services contributed by public-spirited citizens and by members of the faculties of the State agricultural colleges and staffs of the agricultural experiment stations.

A comparison of the institute statistics as given by the several State directors shows wide differences in the number of sessions held, in the attendance, in the amount of money appropriated, the character of the programmes, the number of speakers employed, the cost per session, and in many other important respects. To what extent the differences in the results obtained are due to the varying degrees of efficiency of the methods pursued can only be surmised, but that the methods adopted have affected the work in greater or less degree is undoubted. The fact that one State, with the same or even less expenditure of money, is able to secure more satisfactory results than another is evidence that the one that excels possesses special advantages, or has adopted a more efficient system of administration than the other.

PURPOSE OF THE INSTITUTE.

All earnest farmers' institute workers have the same purpose in view—the improvement of country conditions through the dissemination of valuable information relating to agriculture. The differences that exist in their methods of carrying out this purpose are not as a rule the result of a deliberate intention to be peculiar, but have arisen, as has been stated, out of the conditions that existed when the institutes were organized. The methods, however, in any State are not so fixed in its system as to be incapable of change, or of others being substituted if such change and substitution are found to be best.

The time seems to have come when those who are responsible for the development of the institute work of the country should in some systematic way consider the important questions that the differences in the various methods in use suggest, with a view to improving existing systems by incorporating in all of them such items of recognized value as are likely to be equally advantageous and applicable in all of the States. This no doubt can best be done by first coming to some agreement respecting a few fundamental principles in institute work that ought to be recognized and adopted by every State.

With this in mind, the Farmers' Institute Specialist of the Office of Experiment Stations, United States Department of Agriculture, has been securing data from the farmers' institute workers in all of the States and in foreign countries respecting the various methods that are in use in conducting this work, and after careful consideration and comparison of those that have been most successful with those that seemed to have at least partially failed, has outlined the system that is herewith presented.

While it is not expected, neither is it desirable, that the institute systems of the several States shall ever become uniform in every particular, any more than that the constitutions and laws of the States should become identical in form, yet there are certain fundamental features that appear to be essential which should be incorporated in every institute system that is to secure highest efficiency in its administration and most complete success in accomplishing its educational purposes.

ESSENTIALS OF AN EFFICIENT INSTITUTE SYSTEM.

A brief preliminary discussion of several points held to be essential in any well-constructed farmers' institute system is given in partial explanation of their incorporation into the body of the plan proposed. A full discussion of the items introduced into the plan is for obvious reasons impracticable and is doubtless unnecessary. Most of them are believed to be sufficiently self-evident to need no explanation.

PERPETUITY.

In discussing the essential features of the farmers' institute work and of a system that will secure the ends desired, there arises, first of all, the question of stability. The friends of this movement believe that the institute provides for a need in industrial education that no other institution has yet met, and that it has come to stay. If this is true, then some form of organization that will secure permanency has become a necessity.

It can be stated as a general truth that no institution that is dependent for its continuance or efficiency upon the life or ability of any one man is well founded. Sooner or later such an administration must close its term and a new man or set of men must take control. When this occurs there is almost certain to be a considerable period when the progress of the work is seriously interrupted, and not infrequently the entire system and policy which had been adopted and successfully conducted for years are completely overthrown.

On the other hand, where institutions are so organized and established that all of the important features of their administration are securely fixed by law, removals from position and changes of administration can do no serious harm. The constituted order is preserved and the work goes steadily on decade after decade, accumulating valuable experience and transmitting its methods and its powers unimpaired for the benefit of future generations.

The institute has become a part of our system of industrial education, and its organization, therefore, should be such as will insure its permanent, continued existence. There is but one way to secure this, and that is to have it become a legal body with its powers and duties clearly defined and firmly fixed by law.

LOCAL ORGANIZATIONS.

The second necessary feature to be provided in order that the institutes may be permanent and progressive is that of efficient local organization.

No enterprise requiring the cooperation of the citizen to carry it into effect can long endure unless the individual whose cooperation is required is given a share in the responsibility. There is an interest, vigor, and efficiency created and promoted in placing responsibility upon men that are never developed where they are pauperized by being maintained without exertion of their own. Remove from the township or county the element of personal responsibility for their government and control, and in a short time the majority of the citizens will have lost interest in public affairs and will tamely accept whatever those who rule from distant capitals impose. A strong local organization, recognized by the law, with defined duties and responsibilities, is essential for the perpetuity of the institute, as well as for the best performance of that which it has been created to effect. These local organizations should not be limited to a single society for a county, but should extend to the subdivisions of counties, so as to reach and include the practical farmer and his family by being made easily accessible to every farm home. The average farmer will not, week after week or month after month, travel 10, 15, or 20 miles to attend a meeting of agricultural people but will be glad to be a member of a local club or society that includes his neighbor if it proves itself useful and is within easy reach.

CENTRAL SUPERVISION.

A third element in an institute system that is to secure perpetuity and efficiency to the work is central supervision.

An institution without a head is weak. There must be a competent central organizing power to coordinate and direct or the enterprise will fail. This is so generally recognized and accepted both in governmental and business affairs as to need no demonstration.

In the farmers' institute work a central office is specially necessary. The institute work is so distributed that cooperation between its parts is scarcely possible unless there be some central supervising power to act as a common medium of communication. The interests which the institutes represent are of such magnitude and importance as to require the undivided attention of at least one capable director in each State to properly oversee. To place their control in the hands of a man already overburdened with other responsibilities is in all cases to hinder, and in many to practically destroy, the efficiency of the work. If the duties connected with the supervision of a college with but a few hundred students at most, or of a district school with but a score or two of pupils, require the entire time of the president or of the teacher in charge to properly oversee and conduct, surely a school of agriculture, such as the farmers' institute comprises, with pupils by the ten thousand, needing instruction of the most advanced and technical character, should have the entire attention of at least one man to plan for it and to organize its work.

AGRICULTURAL COLLEGE AND EXPERIMENT STATION COOPERATION.

The fourth essential in any State farmers' institute system is provision for securing the cooperation and assistance of the agricultural college and experiment station.

The institute is an educational institution holding a peculiar place in the system of public instruction. Its distinctive work is to disseminate agricultural information. In this respect it is the field agent of the agricultural college and experiment station. These institutions represent advanced agriculture, and are at the head of the movement for education in agriculture in each State. Their efforts and influence extend into every community, to the workers in the shops and on the farms; in the orchards, vineyards, and stock barns of the people. Their work and that of the institutes are identical in these respects, and the closest union and cooperation should therefore exist between them.

THE INSTITUTE A STATE INSTITUTION.

In order that the institute may be most useful to all of the people and continue to develop most rapidly, it should be as free as possible from political and sectarian strife. To effect this its officers should be elected by men of all political parties and of all religious creeds, and the law fixing its organization should be such as to make such an election possible.

While it should be as free as possible from political control, it at the same time should be so identified with the State administration as to make its financial needs a part of the budget presented to the legislature for meeting the expenses of the several departments of the State government, and its accounts should be subject to audit by State officials. It should in this respect be in a position similar to that now occupied by the State system of public instruction, and while receiving maintenance from the State be under nonpartisan control.

PROPER SUPPORT.

No organization of a public character can long exist and properly progress without some provision for adequate and assured support.

The farmers' institute system that is to serve the purpose of its organization must employ expert specialists to teach, and must have efficient officers to oversee the work. Proper provision for the payment of these lecturers and officers must be made, and this provision should not be of a temporary or uncertain character, but the act providing for the creation of the institute system should also provide for its maintenance and an appropriation should be embodied in the law which will insure continuous and adequate support.

FUTURE DEVELOPMENT.

The institutes are in their primary stage of development. Hitherto they have been, for the most part, mere demonstrations or examples of what is possible in the way of teaching scientific truth to farmers. They have not yet settled down to the giving of regular and systematic instruction. This undoubtedly will come as experience is gained and the means for extending the work are provided.

The future institutes no doubt will, as is now done by a number of European countries, employ lecturers by the year, to be in the field giving regular instruction in itinerant and local schools and in clubs of farmers. This will necessitate changes in present methods that need to be anticipated and provided for in any form of organization that is to be serviceable through the years to come.

OUTLINE OF A SYSTEM.

The legislative act for the establishing of a State system of farmers' institutes and the forms of constitutions and by-laws for State, county, township, and district organization herewith presented have been proposed not with the expectation that either the act or any of the forms will be adopted without modification, but mainly to call attention to a possible system that might be adopted by States where no permanent organization has yet been effected or in which it is still incomplete, and to provide a basis for the discussion of the question of organization in institute work and of the form that will best serve to accomplish the objects which the institute has been created to secure.

Although the system suggested is not in operation in all of its details in any single State, nevertheless every feature has been tested by actual experience and has been successfully applied by institute workers.

The form of organization proposed provides in general for—

(1) A central board of control for the State, acting through an executive officer or State director.

(2) An organization in each county acting through a secretary who is an agricultural expert.

(3) Township organizations subordinate to the county institute society and acting through their several secretaries.

(4) School district clubs composed of families organized by the county and township societies, and holding their meetings at each other's homes.

(5) For nonpartisan control, and for continuous and adequate support.

FORM OF AN ACT OF ASSEMBLY FOR THE CREATION OF A SYSTEM OF FARMERS' INSTITUTES.

AN ACT Providing for the establishing of a system of farmers' institutes for the State and making appropriations for their support.

Section 1. *Be it enacted, etc.*, That a board of administration of farmers' institutes is hereby established to be known under the name and style of the ——— State Board of Farmers' Institute Directors.

Sec. 2. Its purposes shall be to organize farmers' institutes in the several counties; to furnish lecturers who shall give instruction in the institutes; to disseminate useful agricultural information, and to aid in developing the agricultural resources of the State.

Sec. 3. The State board of farmers' institute directors shall consist of the president of the board of regents or other governing board of the State agricultural college; the director of the State experiment station; the dean of the faculty of the school of agriculture in the State agricultural college; the president of the State board of agriculture, or in case no such or similar body exists in the State, then by the president of the oldest incorporated State agricultural organization; the State secretary or commissioner of agriculture, and the State superintendent of public instruction, members ex officio, and of four persons to serve for one year, elected by delegates from county farmers' institute societies, all of whom shall serve without pay, except that their actual and necessary traveling and hotel expenses incurred in attending the annual convention, and the meetings of the board shall be paid by the treasurer of the State upon presentation of properly certified itemized vouchers approved by the secretary of the said board. The seven named ex officio members of the board of directors shall be empowered immediately upon the passage of this act to organize temporarily as a board and exercise all of the powers and perform the duties set forth in section 18 of this act until the four elective members have been elected and qualified.

COUNTY INSTITUTE SOCIETIES.

Sec. 4. When twenty or more persons, over 21 years of age, residents of any county in this State, shall organize themselves into a society to be called the ——— County Farmers' Institute Society, for the purpose of carrying out the objects of this act in accordance with its provisions and in conformity with rules and regulations furnished by the State board of farmers' institute directors, such society shall be deemed a county institute society and a public corporation of the State: *Provided*, That not more than one such county institute society in any county shall be created by this act: *And provided further*, That no person shall be entitled to enrollment as a member or to vote until he or she has signed the constitution of the society and has paid into the treasury of the society an initiation fee of $——, and each year thereafter for continuing membership the sum of $—— annual dues.

Sec. 5. The first meeting for the purpose of organizing a county farmers' institute society shall be called by the State board of farmers' institute directors, to be held at the county court-house of each county, respectively, upon such date as the State board of farmers' institute directors may select, and each of the clerks of the courts of common pleas of the several counties shall give notice of such meetings for organization in two newspapers in each county by two insertions, at least one week apart, and the last one not more than one week prior thereto; he shall also attend the meeting, call it to order and preside until a president be chosen. The expense of the notices so published shall be paid by the respective counties, the bills to be approved by the clerks of the courts of common pleas ordering them.

Sec. 6. The meeting thus called shall organize by enrolling at least 20 members, as provided in section 4, and then proceed to elect a president, a vice-president, and a secretary, and one person from each township in the county to act as a member of the county board of farmers' institute directors to serve until the next regular annual meeting of the society, and until their successors are elected.

Sec. 7. The directors thus chosen shall meet at the county court-house thirty days after the adjournment of the meeting at which they were elected, and organize a temporary county farmers' institute society by electing a president, a vice-president, a secretary, a treasurer, and an executive committee of three members, all to be chosen from among the directors, to serve until the next annual meeting of the society and until their successors are elected, except that the secretary and treasurer may be selected outside of the membership of the board of directors.

Sec. 8. Each temporary institute society thus organized shall immediately report its organization to the State superintendent of farmers' institutes, accompanied by a statement giving the name of the society, the number of members, the name and post-office address of each officer, and a copy of its constitution and by-laws.

Sec. 9. The first annual meeting of each society shall take place on the —— of ———, to be called by its executive committee, at which time a permanent organization shall be effected, and only members shall be entitled to vote.

Sec. 10. The officers of the permanent organization of each of the county farmers' institute societies herein provided for shall be a president, a vice-president, a secretary, a treasurer, and one director from each township in the county, to be elected at the annual meeting of the society by the members thereof from their membership by ballot, to hold office for one year and until their successors are chosen, except that the secretary and treasurer may be elected from outside of the membership of the society, and the secretary shall be elected for three years and until his successor is chosen.

Sec. 11. There shall be an executive committee in each county society, consisting of the president and secretary ex officio, and three directors elected by the township directors from their number, to hold office for one year.

Sec. 12. Each county farmers' institute society shall hold annually a meeting at the county seat upon the —— of ———, at which meeting the members shall elect by ballot officers for the ensuing year and one delegate to the next annual meeting of the State board of farmers' institute directors, and the said delegate is hereby empowered to vote for persons to fill such vacancies as exist or are about to occur in the membership of the said State board, and to make such reports and recommendations respecting the institute work of the State as he may deem proper.

Sec. 13. The county farmers' institute societies shall have authority to form township farmers' institute societies in the townships of their respective counties, in accordance with rules and regulations furnished by the State board of farmers' institute directors: *Provided*, That but one such society shall be created in any one township.

Sec. 14. Any county farmers' institute society shall have power, in cooperation with any township institute society in that county, to form district institute clubs in such township in accordance with rules and regulations furnished by the State board of farmers' institute directors for the purpose of holding local meetings and for cooperation with the township and county institute societies in conducting institute work.

Sec. 15. The treasurer of each county in which a county farmers' institute society has been organized in accordance with the provisions of this act that has held at least one farmers' institute meeting each quarter during the year, and at which lectures and discussions on farm topics were given, and to which the farming public were invited, shall pay to the treasurer of such farmers' institute society properly certified bills for expenses incurred for this purpose to the amount of $100 annually for counties having, according to the last census, 1,000 farms or less, and in counties having over 1,000 farms $50 additional for every additional 500 farms or fraction thereof: *Provided*, That before payment shall be made a certificate shall be presented signed by the secretary of the State board of farmers' institute directors approving the items contained in the said vouchers and certifying that the said county farmers' institute society has complied with all of the conditions imposed upon it by this act.

Sec. 16. Each county farmers' institute society shall, through its secretary, make an annual detailed statement of all of its expenditures for institute purposes, and prepare and forward to the State superintendent of farmers' institutes a full report of the institute work of the year upon blanks to be furnished by the State superintendent of farmers' institutes; and any county farmers' institute society failing or refusing thus to report, or to hold institute meetings as directed in this act, shall be deprived of the benefit of any appropriation from the State or county for that year.

Sec. 17. All county institute societies organized under this act shall be strictly nonpartisan and nonsectarian in every phase of their work, and no institute shall be operated in the interest of any party, grange, alliance, farmers' club, religious sect, or society, but for the equal good of all citizens and farming communities. No fee shall be charged for admission to institute meetings held under this act, but they shall be public and free to all, except that the members of the society shall pay the annual fee of not less than $——, as provided in section 4 of this act.

STATE BOARD OF FARMERS' INSTITUTE DIRECTORS.

Sec. 18. That immediately after the passage of this act the ex officio members of the State board of farmers' institute directors, as provided in section 3, shall meet at the State agricultural college and organize temporarily by the election from their number of a president, a vice-president, and a secretary, and shall prepare and publish rules for the organization of the county farmers' institute societies, shall issue notices to the clerks of the courts of common pleas of the several counties for meetings to organize county farmers' institute societies, and as soon as one-fourth of the counties shall have organized societies, in accordance with the provisions of this act and with the rules of the State board, the said board shall notify them to elect delegates to a State convention to be held at a time to be fixed by the board, for the purpose of electing four persons to membership in said board. The actual and necessary traveling and hotel expenses incurred by the regularly accredited delegates in attendance at the annual State convention held to elect members to the State board of farmers' institute directors, shall be paid by the State treasurer upon the presentation of properly certified itemized vouchers approved by the secretary of the State board of farmers' institute directors.

Sec. 19. Within thirty days after the State convention and the election so held, the State board of institute directors shall meet and organize by the election of a president, a vice-president, and a secretary who shall also be superintendent of farmers' institutes, and an executive committee of five of their number, of which the president of the board and the superintendent of farmers' institutes shall be ex-officio members; all to serve for the period of one year, except that the secretary and superintendent of institutes shall be elected for a term of three years, and until his successor is appointed, at a salary of $—— per year. The board is also empowered to employ such clerks, stenographers, typewriters, and other employees for institute service as it may from time to time find necessary.

Sec. 20. The board shall have the power to fix the salaries of its officers, except that of the secretary and superintendent of farmers' institutes otherwise provided for, and to pay them out of such appropriations as it may receive; to employ and pay lecturers who are to give instruction to the farmers of the State; to aid the county institute societies, both by furnishing lecturers and paying such necessary expenses as they may be authorized to incur for institute purposes, and to do such other acts and things as farmers' institute directors as in their judgment will best promote the interests of the institutes and make them most useful to the agricultural people of the State.

Sec. 21. The board shall, on or before September 1 of each year, report its proceedings for the entire year ending June 30 to the governor, showing in detail the manner of its execution of the provisions of this act, and present such recommendations as it may deem important to make, and such papers and addresses delivered before the farmers' institutes of the State as it may select, said proceedings, report, and papers to be printed and bound to the number of —— thousand copies by the public printer, and to be paid for as other public printing is paid. The said reports shall be apportioned as follows: To the State board of farmers' institute directors, —— copies; to each member of the State senate and house of representatives, —— copies; to each county farmers' institute society organized under this act, —— copies; to the executive department of the State government and to the State library, each, —— copies; to the State agricultural college, the State agricultural experiment station, the state board of agriculture, and to the Secretary of the National Department of Agriculture, each, —— copies.

Sec. 22. A statistical report of the farmers' institute work for the year ending June 30, giving the number of one-day institutes held during the past year, the number of two-day institutes, and the number continuing three or more days; the total number of sessions, with the average attendance per session; the cost of the institutes; the amount appropriated by the State; the amount received from other sources, designating the sources; the number of State lecturers; the number of local lecturers; the number of lecturers supplied by the agricultural college and experiment station, with the days contributed, shall be prepared by the board and forwarded to the Secretary of Agriculture of the United States, on or before September 1 in each year, for incorporation in the annual reports of the Division of Farmers' Institutes of that Department, together with such additional information respecting the farmers' institute work of the State as the said Department of Agriculture may from time to time request.

Sec. 23. All appropriations made by the State for farmers' institute purposes shall be made to this board, to be paid by the State treasurer upon the presentation to the auditor of the State of properly itemized vouchers certified by the president of the board and countersigned by the secretary. The board shall have the sole disposal of the funds thus appropriated, and shall apportion and expend the same in such manner as in its judgment will best promote the interests of the farmers' institute work throughout the State. It shall make no appropriation without funds in hand to meet the same, and the State shall in no event be held liable or responsible for debts, obligations, or contracts made by the board of farmers' institute directors.

Sec. 24. The State board of farmers' institute directors shall have power to fix the dates at which the institutes shall be held within the State; to appoint speakers to address the institute meetings; to review programmes of exercises prepared by the county institute societies, and to strike out objectionable features or to exclude speakers; to district the counties of the State into institute sections; to arrange the itinerary of lecturers; to require reports from time to time respecting the institute work from county institute societies upon blanks which it shall provide; to audit and approve the accounts of the county institute societies, and to require of these societies itemized statements of all receipts and expenditures, with vouchers, at such times as it may direct.

Sec. 25. Rooms at the State agricultural college shall be provided by the State for the use and accommodation of the board of directors, and be fitted with the necessary furniture and office fixtures, which rooms shall be in charge of an officer of the board and during business hours be open to the public.

Sec. 26. The State board of farmers' institute directors shall appoint the executive committee, and the president of the board shall appoint committees on the following subjects: Domestic science, improvement of institutes, rural schools, public roads, experimentation in agriculture; agricultural fairs; circulating libraries and farmers' reading courses, State college and experiment station work, and the improvement of country youth, and shall have power to appoint such additional committees as it may deem necessary.

Sec. 27. It shall be the duty of the State board of farmers' institute directors, in cooperation with the county institute societies, to organize township institute societies and district institute clubs. In furtherance of this it shall prepare and transmit to the county societies forms of organization for the township societies and district clubs, together with sets of rules for their guidance, which form of organization and sets of rules shall be uniform for the State and be framed with a view to uniting all institute societies in one common institute system.

Sec. 28. It shall be the duty of the State board of farmers' institute directors to encourage the formation of institutes for women and make such appropriations for their support as it may deem best. It shall also secure circulating libraries of agricultural literature and aid in their distribution among the farmers of the State, and take such measures as it shall deem effective to interest the young people of the country in agricultural education.

Sec. 29. All necessary expenses under the provisions of this act shall be paid by the State treasurer, upon the presentation of itemized vouchers approved by the president and secretary of the State board of farmers' institute directors: *Provided*, That not more than $—— shall be expended in any one year.

Sec. 30. The board of directors is empowered to make and enforce such rules and by-laws not in conflict with the laws of this State as it may deem necessary for conducting its business and for the effective carrying out of the true intent and purposes of this act.

BY-LAWS FOR A STATE BOARD OF FARMERS' INSTITUTE DIRECTORS.

Whereas by act of assembly approved ——— ——, 190—, the ——— State board of farmers' institute directors was created, empowering it to make rules and by-laws for its government and the management of its business, the following by-laws are hereby adopted:

ARTICLE I.—DIRECTORS.

SECTION 1. The board of directors shall hold a meeting in the institute rooms at the State agricultural college on the third Wednesday after the annual meeting of the county institute delegates to elect directors, the old board to dispose of its business, the new board to organize, elect officers, and outline its policy for the ensuing year, and transact such other business as may come before the board.

SEC. 2. The board of directors shall also meet between the 1st day of September and the 10th day of October in each year, the date and place to be designated by the president in his call for the meeting.

SEC. 3. Special meetings of the board of directors may be called by the president by giving ten days' notice thereof; or upon a written petition signed by four members of the board the secretary shall call a meeting.

SEC. 4. The board of directors shall fix the salaries of all officers except that of the secretary before the election to fill said offices.

SEC. 5. Five members of the board shall constitute a quorum for the transaction of business.

ARTICLE II.—OFFICERS.

SECTION 1. The officers of the board of directors shall consist of a president, a vice-president, and a secretary, who shall also be State superintendent of farmers' institutes, all to be elected by ballot to serve for one year and until their successors are elected and qualified, except in the case of the secretary and superintendent of farmers' institutes, who shall be elected for a period of three years and until his successor is elected and qualified.

SEC. 2. The officers of the board must be members of the board, except the secretary, who may be other than a member of the board.

ARTICLE III.—PRESIDENT AND VICE-PRESIDENT.

SECTION 1. The president shall be the chief executive officer of the board of directors; shall appoint all committees except the executive committee; he shall be ex-officio member of all standing committees; he shall preside over all of the meetings of the board and of the executive committee, sign all warrants for expenditures, approve all bills, and perform such other duties as are usual to a presiding officer.

SEC. 2. In case of the absence or disability of the president, or in case of a vacancy in that office, the vice-president shall perform his duties.

SEC. 3. In case of the absence or disability of these officers, or in case both offices become vacant, any director or member of the executive committee who is called to the chair shall act as the president for the time, and sign all necessary papers.

ARTICLE IV.—SECRETARY.

SECTION 1. The secretary shall also be superintendent of farmers' institutes; shall attend and keep a record of all meetings of the board of directors and of the executive committee; he shall act as secretary of the annual meeting of delegates to elect State directors, and shall keep minutes of the proceedings; he shall countersign and approve orders upon the State treasurer for all proper expenditures, and shall have charge of the books of account.

SEC. 2. He shall, under the direction of the board of directors and of the executive committee, have supervision of the farmers' institutes held in the State; he shall make recommendations as to the lines of work which he believes will prove most profitable, and shall submit all plans and arrangements for farmers' institute work for the approval of the board or the executive committee. He shall visit county institutes and district meetings when so directed by the board or executive committee, or when, in his judgment, the institute work demands such visit.

SEC. 3. He shall be librarian of the State farmers' institute free libraries, when such are established, and shall submit to the board of directors or to the executive committee for approval lists of books which he deems ought to be purchased for the use of the libraries.

Sec. 4. He shall have a permanent office at the State agricultural college, under the control and supervision of the board, which office shall be supplied and maintained at the expense of the State, and he shall be the custodian of all the reports and papers belonging to and all property owned by the State board of institute directors, and shall report an inventory of all property of the board of directors at the close of each fiscal year. He shall collect such of the papers, addresses, and discourses given at the various farmers' institute meetings as he shall deem proper and advisable to publish, shall edit the same, and upon approval by the board shall cause them to be printed in a volume to be known as the "Farmers' Institute Annual." He shall also make a report in writing at the close of each institute year to the board, giving a full account of the institute meetings held, the attendance at each meeting, the list of speakers at the various meetings, the items of expenditure during the year, together with a general survey of the work of the year, and embodying such recommendations for the improvement of the work as he may deem best to make, the whole or a summary of this report to be published in the Farmers' Institute Annual. He shall make such other reports during the year as the board of directors or the executive committee may desire, and perform such other acts and duties as the office of the secretary and superintendent of farmers' institutes may require.

ARTICLE V.—STANDING COMMITTEES.

Section 1. The duties of the standing committees, unless otherwise provided for by these by-laws, shall be suggestive and recommendatory in character. They shall meet at the same time and place that the board of directors' meetings are called, and report to the board of directors the progress made in and all the needs of their respective lines of work.

ARTICLE VI.—EXECUTIVE COMMITTEE.

Section 1. The executive committee shall conduct the affairs of the State board of farmers' institute directors in the interval between the meetings of the board, in accordance with the rules and regulations adopted by said board.

Sec. 2. It shall meet on the call of the president of the board of directors and shall be the official adviser of the State superintendent of institutes when the board of directors is not in session; it shall pass on all bills before they are paid, and upon all arrangements submitted to it by the State superintendent for holding State farmers' institutes, the selecting of speakers, the preparation of programmes, and the fixing of dates for the county institutes. The committee shall at the close of the year submit its minutes to the board of farmers' institute directors for information and approval.

ARTICLE VII.—COMMITTEE ON DOMESTIC SCIENCE.

Section 1. The committee on domestic science shall devise and recommend to the board of directors means for the establishing and conducting of women's domestic science associations in connection with the farmers' institute work.

ARTICLE VIII.—COMMITTEE ON IMPROVEMENT OF FARMERS' INSTITUTES.

Section 1. The committee on improvement of farmers' institutes shall take into consideration the methods adopted in the management of county and district farmers' institutes; the programmes submitted, the arrangement of circuits for institute meetings, the employment of speakers, and make report to the board, with such recommendations for improvement on these lines as they may deem best.

ARTICLE IX.—COMMITTEE ON RURAL SCHOOLS.

Section 1. The committee on rural schools shall collect information in regard to the character of instruction given in the rural schools; the degree to which agricultural subjects are taught in those schools, and the method of teaching; the location of schools in which agriculture is taught, and report to the board on the progress made.

ARTICLE X.—COMMITTEE ON PUBLIC ROADS.

Section 1. The committee on public roads shall collect information in regard to the public roads of the State and submit to the board at its annual meeting recommendations for their improvement.

ARTICLE XI.—COMMITTEE ON EXPERIMENTATION IN AGRICULTURE.

SECTION 1. The committee on experimentation in agriculture shall investigate the subject of cooperative experimentation and demonstration farms among farmers, with a view to the discovery of the best methods for organizing and conducting this work. The committee shall make report to the board of directors at its annual meeting.

ARTICLE XII.—COMMITTEE ON AGRICULTURAL FAIRS.

SECTION 1. The committee on agricultural fairs is charged with the duty of investigating the county fair associations of the State and of reporting their condition to the board of directors at its annual meeting with suggestions for increasing their usefulness.

ARTICLE XIII.—COMMITTEE ON CIRCULATING LIBRARIES AND FARMERS' READING COURSES.

SECTION 1. The committee on circulating libraries and farmers' reading courses shall make a careful study of what is being done in these directions and suggest to the board at its regular annual meeting such additions and improvements as it may deem best in order to extend most widely the benefits of these features of the institute work.

ARTICE XIV.—COMMITTEE ON THE AGRICULTURAL COLLEGE AND EXPERIMENT STATION.

SECTION 1. The committee on the agricultural college and experiment station shall each year visit these institutions in order to familiarize themselves with their work, and shall make report to the board of farmers' institute directors, suggesting and recommending methods by which the institutes can be most helpful in promoting their interests.

ARTICLE XV.—COMMITTEE ON THE IMPROVEMENT OF COUNTRY YOUTH.

SECTION 1. The committee on the improvement of country youth is charged with the duty of devising means for the improvement of the young people throughout the rural districts, and is directed to submit each year a report to the board upon this subject at its annual meeting.

ARTICLE XVI.—AMENDMENTS.

SECTION 1. These by-laws may be amended at any regular meeting of the board of directors by a majority of all of the members of the board voting in the affirmative, but such amendment must be submitted in writing, filed with the secretary, and read at two regular meetings next preceding that on which the vote is taken.

CONSTITUTION FOR A COUNTY FARMERS' INSTITUTE SOCIETY.

NAME.

ARTICLE I. This organization shall be known as the ——— County Farmers' Institute Society.

OBJECT.

ARTICLE II. The object of this society shall be to assist and encourage useful education among farmers and to develop the agricultural resources of this county by means and through the holding of farmers' institutes in cooperation with the State board of farmers' institute directors, as provided by the act of assembly creating that board; by organizing and aiding township institute societies and district farmers' clubs; by disseminating useful agricultural information; by teaching better methods in general farming, stock raising, dairying, fruit culture, and other branches of agricultural industry; and in general to promote the moral, intellectual, social, and material welfare of the community.

MEMBERSHIP.

ARTICLE III. Any resident of the county of legal age may become a member of this society by signing the constitution and paying a matriculation fee of —— cents, and may continue membership by the payment each year of —— cents and dues. Only members of the society shall be entitled to vote.

OFFICERS.

Article IV. The officers of the society shall consist of a president, a vice-president, a secretary, a treasurer, one director from each township, and an executive committee of five, of which the president and secretary shall be ex officio members.

PRESIDENT AND VICE-PRESIDENT.

Article V. It shall be the duty of the president to preside at all meetings of the society and of the executive committee, and he shall have authority to call special meetings. In the absence of the president the vice-president shall perform his duties.

SECRETARY.

Article VI. It shall be the duty of the secretary to keep a record of the proceedings of all meetings of the society and of the executive committee; to keep a roll of the members, with the post-office address of each, and to conduct all correspondence relating to the business of the society. At the close of the annual institute he shall make out a detailed statement of the expenses of the institutes for the year and forward a copy to the State superintendent of farmers' institutes, together with a report of the work of the institute for the year just closed. He shall visit and assist in organizing township institute societies and district clubs, and arrange for delivering courses of lectures before the township societies and district clubs during the year. He shall be the librarian of the society and attend to such other duties in connection with the county institute work as he may be directed by the executive committee to perform. His salary shall be fixed by the board of directors.

TREASURER.

Article VII. It shall be the duty of the treasurer to receive all moneys belonging to the society and to pay out the same on the written order of the executive committee.

EXECUTIVE COMMITTEE.

Article VIII. It shall be the duty of the executive committee to make arrangements for institute meetings, to engage halls, select local speakers, arrange for music, prepare programmes, and submit the same to the State superintendent of farmers' institutes for approval, to advertise the meetings, to contract and order the payment of bills, to audit and settle accounts made for the society, to assist in organizing township institute societies and district farmers' clubs, and to aid in providing lecturers to give instruction in township and district meetings.

ANNUAL MEETING.

Article IX. The institute year shall begin July 1 and end June 30. The annual meeting for the election of officers shall be held at a date to be selected by the executive committee of the society, between the 1st and 20th of June of each and every year. The annual meeting shall be advertised by mailing to each member, at least ten days before the date thereof, an announcement calling the members together; said announcement shall specify the date, place, and hour of the meeting, and shall contain a programme of said meeting. Posters and newspaper advertising may also be employed to make the meeting publicly known.

ELECTION.

Article X. All officers of the society shall be elected at the annual meeting to be called as prescribed in Article IX. The election shall be by ballot, and none but members shall be entitled to vote. The president, vice-president, treasurer, and a director from each township shall be elected annually, except that in townships where institute societies exist no directors shall be elected by the county society, the president of the township institute society being ex officio a member of the board of county farmers' institute directors, and except that the secretary shall be elected every third year. When a vacancy occurs an election shall then be held to fill the unexpired term. All of the officers shall be elected from the membership of the society, except that the secretary and treasurer may be chosen from others than members. At that meeting there shall also be elected a delegate to attend the meeting to elect State directors of farmers' institutes.

QUORUM.

Article XI. Ten members shall constitute a quorum.

ORDER OF BUSINESS.

Article XII. The order of business to be observed at the meeting of this society shall be ———.

GOVERNMENT.

Article XIII. This society shall be governed by the usual parliamentary rules, and shall at all times conform to the laws of the State creating it and to the rules of the State board of farmers' institute directors.

AMENDMENTS.

Article XIV. This constitution may be amended by a vote of two-thirds of the members of the society taken at any regular meeting, but such amendment must be submitted in writing, filed with the secretary, and read at two regular meetings next preceding that on which the vote is taken.

CONSTITUTION FOR A TOWNSHIP FARMERS' INSTITUTE SOCIETY.

NAME.

Article I. This organization shall be known under the name of the ——— Township Farmers' Institute Society.

OBJECT.

Article II. The object of this society shall be to cooperate in farmers' institute work with the county farmers' institute society, and to aid in organizing and in promoting interest in district farmers' clubs in this township.

OFFICERS.

Article III. The officers of this society shall be a president, a vice-president, a secretary, a treasurer, and an executive committee of five persons, two of whom shall be the president and the secretary of the society. The president is also by virtue of his office the representative of the society on the board of the county farmers' institute directors.

DUTIES OF OFFICERS.

Article IV. The duties of the president shall be to preside at all meetings of the society and of the executive committee; to represent the society on the board of the county farmers' institute directors; to sign all orders on the treasurer, previously approved by the executive committee, for the payment of bills; to call special meetings of the society, and to perform such other duties as are usual to the office of president. In the absence of the president the vice-president shall perform his duties.

SECRETARY.

Article V. It shall be the duty of the secretary to attend all meetings of the society and of the executive committee and keep a record of the proceedings; to take charge of and preserve all papers, documents, and other property of the society; to act as librarian and attend to such duties as that office may require; to make out annually a report of the work of the society and transmit it to the secretary of the county farmers' institute society; to keep the roll of members; issue notice of meetings called by the president or by the executive committee; conduct correspondence, and perform such other duties as are usual to the office of secretary.

TREASURER.

Article VI. It shall be the duty of the treasurer to receive all moneys and to pay out the same on the written order of the president after approval by the executive committee; he shall collect all fees and dues of members and keep a correct account of all moneys received and expended; he shall each year, at the annual meeting, present an itemized report, showing the receipts and expenditures for the year, accompanied by properly signed vouchers for such expenditures, and submit his books and accounts to the executive committee for auditing.

EXECUTIVE COMMITTEE.

Article VII. The executive committee shall make all contracts and approve all bills for the society, and at the close of the year audit the accounts of the treasurer; it shall arrange programmes for township institutes; select local speakers and engage halls for meetings; call such special meetings as may be found necessary; and arrange for meetings of the county institute when they are appointed for that township, and in all respects act as the executive of the society.

MEMBERSHIP.

Article VIII. Any person of good moral standing may become a member of this society by signing the constitution and agreeing to support the rules and regulations made in pursuance thereof, and by paying $—— annually into the treasury. Honorary memberships may be conferred in consideration of eminent character and service, and shall be conferred without fee or dues. The recipient shall not be entitled to hold office, but may take part in all discussions and vote on all questions.

MEETINGS.

Article IX. There shall be at least four meetings held each year at intervals of three months. All meetings shall be open to the public. There shall be no charge for admission to any meeting, and no collection shall be taken. An annual meeting for the election of officers shall be held between the —— day of ——— and the —— day of ———, at a date to be fixed by the executive committee. Due notice shall be given by the secretary to all members of the date and place of the annual meeting and at least ten days before the meeting is to occur.

ELECTIONS.

Article X. The election of officers shall be by ballot and shall be for one year, except that the secretary shall be elected for three years. None but members shall be entitled to vote. The terms of office shall begin at the close of the annual meeting.

AMENDMENTS.

Article XI. This constitution can be amended by two-thirds of the members present voting in the affirmative; but such amendment must be submitted in writing, filed with the secretary, and read at two regular meetings next preceding that on which the vote is taken.

BY-LAWS FOR A TOWNSHIP FARMERS' INSTITUTE SOCIETY.

MEETINGS.

Article I. This society shall assemble quarterly. The time and place of the meetings may be altered at any regular meeting of the society by a vote of two-thirds of the members present.

QUORUM.

Article II. Seven members shall constitute a quorum for the transaction of business; a less number may meet, maintain a discussion on any topic, and adjourn to any given time. Persons present, not members of the society, may be invited to take part in all discussions of agricultural topics, but they shall not take part in the business of the society.

LIBRARY.

Article III. There shall be a library established for the use of the society which shall be open to the free use of the members. It shall be maintained by voluntary contributions and donations of the members and shall be in charge of the secretary of the society. There shall be a library committee of three members appointed at each annual meeting, of whom the secretary shall be one and ex officio chairman, which shall have charge of the purchase and collecting of books, papers, and pamphlets for the library and perform such other duties as that office may require.

AMENDMENTS.

ARTICLE IV. These by-laws may be amended in the same manner as the constitution.

CONSTITUTION FOR A DISTRICT FARMERS' CLUB.

NAME.

ARTICLE I. This society shall be called the ——— Farmers' Club.

OBJECT.

ARTICLE II. The object of this club shall be the social, moral, and intellectual improvement of its members, and the promotion of their common and individual interests as agricultural people. To this end they pledge themselves to cooperate with each other in carrying out the duties enjoined by this constitution, and to aid the township and county institute societies in conducting farmers' institute meetings, and the State board of farmers' institute directors, the State agricultural college, and the State agricultural experiment station in their efforts to improve the agricultural people of the State.

OFFICERS.

ARTICLE III. The officers shall be a president, a vice-president, a recording secretary, a corresponding secretary, and a treasurer.

ARTICLE IV. The duties of officers shall be such as are usual to those positions.

ELECTION.

ARTICLE V. The officers shall be elected by ballot annually at the June meeting of the club to serve for one year and until their successors are elected.

MEMBERSHIP.

ARTICLE VI. The active members of this club must be engaged in agricultural pursuits.

HONORARY MEMBERS.

ARTICLE VII. Honorary members may be elected by unanimous vote.

NUMBER OF MEMBERS.

ARTICLE VIII. The membership shall not exceed twelve families.

APPLICATIONS FOR MEMBERSHIP.

ARTICLE IX. Applicants for membership must have their names submitted at the meeting previous to the one they are invited to attend, and on receiving a two-thirds vote by ballot shall be declared elected.

NUMBER OF MEETINGS.

ARTICLE X. The club shall meet once each month at the residence of one of its members.

MONTHLY ADDRESS.

ARTICLE XI. Each member in turn shall be required to prepare a paper upon some agricultural subject, to be read at the meeting to be held at his house.

DUES.

ARTICLE XII. The annual dues of the club shall be —— cents, to be paid to the treasurer.

REPORTS.

ARTICLE XIII. The secretary of this club shall, as soon after the close of the meeting as possible, prepare a report of the proceedings and transmit it to the county newspapers for publication as an item of news, and a copy to the secretary of the county farmers' institute society for filing with his records. At the close of the year the secretary shall make out a report of the work of the club for the year and transmit it to the secretary of the county institute society, together with a list of its newly elected officers and their post-office addresses and the number of members on the roll.

TREASURER.

ARTICLE XIV. The treasurer shall pay out no money except upon the written order of the president.

UNIT OF MEMBERSHIP.

ARTICLE XV. The unit of membership shall be the family. Election of the head of the family to the club shall admit the other members.

QUORUM.

ARTICLE XVI. Five members shall constitute a quorum for the transaction of business.

AMENDMENTS.

ARTICLE XVII. This constitution may be altered or amended at any stated meeting by the affirmative vote of two-thirds of the members present, but any proposition to that effect must be made in writing, filed with the secretary, and read at two regular meetings next preceding that on which the vote is taken.

BY-LAWS FOR A DISTRICT FARMERS' CLUB.

SECTION I. The meetings shall be held on the —— day of each month at 10 a. m. at the residences of the various members of the club. The place of each meeting shall be designated and announced by the president. The selection shall, as far as possible, be in alphabetical order, but before any selection is made the president shall first ascertain whether it will be convenient for the member next in turn. If found satisfactory, the announcement shall be made before the meeting adjourns.

SEC. II. The extending of invitations to the meetings shall be limited to the hostess of the day.

SEC. III. Any member who shall absent himself from four successive meetings without a reasonable excuse to be accepted by the club shall have his name stricken from the list of members.

SEC. IV. Any member not complying with Article XI of the constitution of this club shall pay a fine of $—— to the treasurer.

SEC. V. The introduction of topics other than those of an agricultural character will be considered out of order during the sessions of the club unless admitted by unanimous consent.

SEC. VI. Each member is expected to keep an accurate record of one or more crops, giving such data respecting them as may be deemed interesting or useful, the record to be handed to the secretary to be read for the benefit of the club.

SEC. VII. The members are required to cooperate in conducting one or more experiments in agriculture. They are also expected to test such new and improved varieties of seeds and plants as they may select or the club supply; to keep accurate records of the experiments and tests and make known to the club the results.

SEC. VIII. The members of this club are required to cooperate with the county and township institute societies in conducting farmers' institutes in the country, and with the agricultural and State experiment stations in their educational and experiment work.

SEC. IX. When voting by ballot each family of two or more shall be entitled to two votes.

SEC. X. Business shall be conducted as follows:

(1) Called to order by the president at 10 a. m.
(2) Calling the roll and reading the minutes of the last meeting.
(3) Election and introduction of new members.
(4) Unfinished business, including answers to referred questions.

(5) Reports of experiments and discussions respecting them.

(6) Reading of paper prepared by the host or hostess, followed by discussion.

(7) Inspection by the men of the premises, the farm, the system of culture, the stock, the farming implements, the gardens, buildings, etc., with criticisms and suggestions; and of the house and surroundings by the women.

(8) Each member shall be asked in turn by the president whether he has any question to propose to the club, and when a question is thus asked, each member shall be required to give his opinion respecting it, after which a vote shall be taken and the secretary shall note the vote of the club in the minutes.

(9) New business.

(10) Announcement of the place of the next meeting.

(11) Adjournment.

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Bulletin No. 79. Farmers' Institutes: History and Status in the United States and Canada. By L. H. Bailey. Pp. 34. 1900.

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 166.

A. C. TRUE, Director.

COURSE IN CHEESE MAKING

FOR

MOVABLE SCHOOLS OF AGRICULTURE.

BY

L. L. VAN SLYKE, Ph. D.,

Chemist, New York State Agricultural Experiment Station.

1862 1889

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 166.

A. C. TRUE, Director.

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COURSE IN CHEESE MAKING

FOR

MOVABLE SCHOOLS OF AGRICULTURE.

BY

L. L. VAN SLYKE, Ph. D.,
Chemist, New York State Agricultural Experiment Station.

1862 1889

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., February 5, 1906.

Sir: I have the honor to submit and to recommend for publication as Bulletin 166 of this Office, a Course of Instruction in Cheese Making for Movable Schools of Agriculture, prepared by L. L. Van Slyke, chemist of the New York State Agricultural Experiment Station. The intent of the projected series of courses of which this is the first is, as explained by the Farmers' Institute Specialist of this Office, to give more extended and specific instruction in agriculture outside of regularly organized schools than is now being given in the farmers' institutes of the country. The value of such instruction has been clearly demonstrated in many foreign countries and there seems to be a real and growing need for it in the United States, especially in those States where farmers' institutes have been longest in operation.

The subject of cheese making has been reduced to relatively satisfactory pedagogical form, and it is therefore hoped that the course herewith submitted will serve to indicate what may be done in the preparation of similar courses in other subjects, many of which will doubtless have a wider application in this kind of instruction.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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PREFATORY NOTE.

This course of instruction in cheese making by L. L. Van Slyke, Ph. D., chemist of the New York State Agricultural Experiment Station, Geneva, N. Y., is the first of a series upon various agricultural subjects to be issued by the Office of Experiment Stations for use by the farmers' institute workers in giving instruction in movable schools of agriculture. The need for more extended and specific instruction, outside of regularly organized schools, than is now being given in the farmers' institutes is becoming felt, particularly in those States where the institutes have been longest in operation.

The course in cheese making consists of fourteen lectures, accompanied by fourteen distinct practicums. There are also given lists of references to literature of the subject, as well as of books intended for a library for general use by the students. There is likewise a list of apparatus needed in giving instruction, together with the price of each item.

The plan consists in the formation of classes of not less than eight nor more than fifteen persons who are interested in cheese making, and giving them daily instruction on this subject, continuing for fourteen days, one lecture each day, each lecture to be accompanied by a practicum by the students of from one to two hours under the supervision of the lecturer. The lecturer may also in some cases visit students at their homes and give such particular assistance and advice for the making of cheese as may be best adapted to their individual circumstances and needs.

The equipment of class rooms, apparatus, books of reference, chemicals, and materials (e. g., milk and cream) needed in instruction, together with other incidental expenses, may be provided for by arrangement between the students in each locality and the State director of farmers' institutes. The latter will, however, select the instructor or instructors and provide for their compensation, as far as the laws relating to such work in the several States will permit.

All arrangements for the movable schools are expected to be made by the State director of farmers' institutes, who will plan for such number as he may see fit, and no one should be admitted as a student in a course who will not first agree in writing to attend every session and perform all of the duties assigned.

Through the instrumentality of these schools it is believed that large numbers of the young men and women who take advantage of the expert teaching thus provided will receive such impressions and acquire such facility in doing the things taught as will result in a greatly improved agricultural practice.

John Hamilton,
Farmers' Institute Specialist.

COURSE IN CHEESE MAKING FOR MOVABLE SCHOOLS OF AGRICULTURE.

GENERAL SUGGESTIONS TO TEACHERS.

It should hardly be necessary to say that no one should attempt to use this course of lectures for the purpose planned unless he has had extended, practical, and successful experience in making Cheddar cheese. The outlines are to be used as a source of suggestions rather than as a rigid system to be followed in every detail in just the order given. The successful teacher has methods and ideas of his own for imparting instruction and adjusts other systems to his own, selecting what he regards as most useful; but at the same time he must always possess an open mind, ready to appreciate and utilize new suggestions and so more or less constantly modify his own methods in the line of greater efficiency.

Some may think it wise to follow the course in detail in the order given, laying a thorough foundation before taking up the actual details of cheese making. Others may prefer to start with making cheese, calling attention only to general points and from day to day repeating the operation of cheese making with greater attention to minute details. Whatever the order of handling the subject may be, most of the material embodied in the lectures should be utilized, if possible, at some time during the course of instruction.

The ideal conditions for carrying on such instruction are, of course, in a well-equipped cheese factory. The only special requirements will be small vats or a large vat divided into small compartments, so that one can work with 100 pounds of milk, if necessary. For learning the manipulations of cheese making, skim milk will answer every purpose and avoid the risk of wasting whole milk.

The teacher must keep in mind the following facts in imparting knowledge to students: (1) One must know much more than mere methods. It is not sufficient for the teacher or the student to know merely how to make cheese, but for the highest success it is quite as important to know as well the reasons for every step of the methods. Try always to inspire your students with the questioning spirit, so that they will constantly be asking to know "why." (2) One must acquire the habit of close and accurate observation. This is absolutely essential in successful cheese making, where much depends on being able to observe indications which completely escape any ordinary, untrained observer. (3) Students must be taught the necessity of acquiring the habit of making a careful, accurate record of all observations. Their notes should be inspected from day to day and criticised and discussed. (4) Students must be taught the absolute necessity of appreciating and paying the closest attention to every smallest detail. Cheese making involves many details. While they are not all of equal importance, each must receive its full attention in its proper place. One who can not learn to appreciate and look after details can never make a successful cheese maker. (5) From beginning to end the absolute importance of cleanliness must be impressed in every way possible.

Teachers can not overestimate the necessity of making each student do every detail of work, at first under close supervision, but gradually with a growing degree of independence, as each shows an increasing mastery of the work.

SYLLABUS OF A COURSE OF LECTURES ON CHEESE MAKING.

FIRST LECTURE.

THE COMPOSITION OF COW'S MILK.

It is important to study the material out of which cheese is made in order to understand the changes that take place and the reasons for the operations performed. Illustrate (1) by action of rennet upon the milk casein, and (2) by action of acid upon curd.

1. *Constituents of milk.*—The most abundant constituents of milk are (1) water, (2) fat, (3) calcium casein (casein), (4) albumin, (5) milk sugar, and (6) salts. The compounds of special interest in cheese making are calcium casein, milk fat, milk sugar, salts, and galactase.

2. *Calcium casein.*—Calcium casein (reference No. 1, p. 36),[a] ordinarily called casein, is the most important nitrogen-containing compound or proteid contained in milk, (1) because it is the one present in largest quantity and (2) because its properties make possible the conversion of milk into cheese. Calcium casein is a prominent constituent of separator slime, being gelatinous in appearance (reference No. 2, p. 94). It exists in the form of very small, solid, jelly-like particles in suspension and not in solution.

Composition of calcium casein and casein.—Casein contains carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulphur. Casein as such does not exist in milk, but only in combination with about 1.50 per cent of calcium oxid (lime) (reference No. 1, p. 11), this compound being calcium casein.

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[a] The references in these lectures are to the list given in the appendix, p. 61.

Action of acids on calcium casein.—When an acid is added to milk, its first action is to unite with certain salts of the milk and then with the calcium of calcium casein, forming a precipitate of free casein. On further addition the acid unites with the casein, forming a casein salt of the acid used, as in the case of sour milk, when casein lactate is formed. If a large amount of acid is added to milk, the casein is first coagulated and then dissolved, as in the case of the Babcock test.

Action of alkalis on casein compounds.—Alkalis, like ammonia, caustic soda, carbonate of soda, etc., unite with casein compounds, forming compounds soluble in water. They also dissolve casein coagulated by acids.

Action of heat on casein compounds.—Heat alone under ordinary conditions, even at the boiling point, coagulates calcium casein little, if any. The skim formed on the surface of milk heated above 140° F. contains practically all the constituents of milk and is primarily due to the presence of calcium casein and not to albumin, as formerly supposed.

Action of rennet on calcium casein.—Coagulation by rennet in the presence of soluble lime salts is one of the most characteristic properties of calcium casein. The manufacture of cheese from milk depends upon this property. The compound or curd formed by treating milk with rennet is called calcium paracasein, but does not differ much from calcium casein (reference No. 1, p. 30). The coagulation of calcium casein by rennet is entirely different from that produced by acids (reference No. 1, pp. 22 and 30). The properties of rennet and the conditions that affect its power to coagulate calcium casein will be considered in Lecture 6.

3. *Milk fat or butter fat.*—Milk fat is a mixture of several different compounds, chief of which are palmitin, olein, myristin, and butyrin. Each of these compounds contains glycerin united with an acid (reference No. 3, p. 13), and each varies in its properties from the others (reference No. 3, p. 14). Milk fat in pure, fresh condition is a soft whitish to yellowish mass, of mild taste and only slight odor. It melts easily and is lighter than water. Milk fat is present in milk in the form of minute, transparent globules, averaging about one ten-thousandth of an inch in diameter (reference No. 3, p. 14). The fat globules are not surrounded by any kind of special covering (reference No. 3, p. 14), but are simply minute particles of fat floating free in the form of an emulsion.

The amount of fat in milk is affected by many conditions, among which are individuality, breed, age, stage of lactation, time of milking, and so forth (reference No. 3, pp. 15–17). The direct relation of milk fat to cheese yield will be considered later.

4. *Milk sugar.*—Milk sugar is present in cow's milk in solution. Its importance in relation to cheese making is due to the readiness with

which it is converted into lactic acid by various organisms. (See Lecture 6, paragraph 1.) Experiment—see page 17.

5. *Salts.*—The salts of milk, also called mineral matter or ash, are present in small quantities, but are very important. The relation of the lime (calcium) salts to cheese making will be pointed out later. (Lecture 9, paragraph 3.)

6. *Galactase.*—(See Lecture 6, paragraph 5.)

7. *Amounts of constituents in milk of representative character.*—(*a*) The average of 5,552 American analyses of milk compiled by the writer is as follows: Water 87.1 per cent, total solids 12.9 per cent, fat 3.9 per cent, calcium casein 2.5 per cent, albumin 0.7 per cent, sugar 5.1 per cent, and ash 0.7 per cent.

(*b*) Variation in composition of cheese-factory milk during the season (May to October).

In the following table are given the lowest, highest, and average results for the composition of milk during the cheese-factory season:

Variations in composition of milk.

Milk constituents.	Lowest.	Highest.	Average.	Milk constituents.	Lowest.	Highest.	Average.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
Water	86.61	87.71	87.38	Casein	2.19	2.66	2.41
Total solids	12.29	13.39	12.62	Albumin	.58	.88	.72
Fat	3.70	4.10	3.73	Sugar, ash, etc	5.58	6.03	5.76

EXPERIMENT AND PRACTICE WORK, FIRST LECTURE.

Time required for experiments.—The work prescribed in these experiments will require from one to two hours of continuous work, according to the facility of individual students in performing the manipulations. As indicated, a part of the work will be carried over until the day following for final observation.

Apparatus required.—(1) Pipette or graduate to hold 10 cubic centimeters, (2) teacup or glass tumbler or test tube or beaker, (3) common sal soda, (4) whey, and (5) microscope and accessories.

1. *Action of acids on calcium casein* (*casein*) *of milk.*—To 10 cubic centimeters of sweet milk in a teacup or glass add 100 cubic centimeters of water. Warm to 100° F. and add some strong vinegar (impure dilute acetic acid) drop by drop, shaking or stirring vigorously. Continue to add vinegar and agitate until a white, solid substance separates. This substance is casein acetate, formed by the union of the acetic acid and the casein of the milk, and it is insoluble in water. Pour off the water from the solid white substance and then add carefully about 15 or 20 cubic centimeters of sulphuric acid such as is used in Babcock test. What happens to the white substance (reference No. 1, p. 21)?

2. *Action of alkalis on casein compounds.*—Prepare some casein acetate, as described in preceding experiment. Dissolve some sal soda in water and add some of this solution to the white, solid casein acetate. Agitate. The casein acetate is dissolved, the casein combining with sodium, forming sodium caseate, which is easily soluble in water.

3. *Preparation of milk sugar.*—Take a pint or more of whey and evaporate it to about one-eighth of its original bulk. Let it stand until the next day. Impure milk sugar separates in solid form. How does it compare in sweetness with cane sugar? Place some of it on a stove or hot iron. What is the odor produced?

4. If a good microscope is available, place one drop of diluted milk (1 part of milk diluted with 10 parts of water) on a glass slide, put a cover glass over it and examine with different magnifying powers. Study the fat globules, noticing their variation in size. Take a small piece of cheese and mix it very completely with several times its bulk of warm water. Then take one drop of this water extract and examine it under the microscope for fat globules. Examine a drop of undiluted whey and of skim milk.

5. Melt about half a pound of butter and pour it into a glass tumbler. Let it stand twenty-four hours at 60° to 80° F. Notice the separation of fat from the brine. Notice the granular structure of the fat and the fact that some of it appears to be more or less liquid through the mass. This shows that butter fat contains different fat compounds.

SECOND LECTURE.

THE COMPOSITION OF COW'S MILK IN RELATION TO THE MANUFACTURE OF CHEESE.

Only within fifteen years has there been a thorough study of the relations of milk to cheese. The whole attention was formerly given to methods of cheese making, and none to such fundamental questions as the relation of fat and casein in milk to yield and quality of cheese, the character and extent of losses of milk constituents in cheese making, their causes and remedies, etc.

1. *Yield of cheese variable with different milks.*—It is a fact of common experience at cheese factories that the amount of cheese made from 100 pounds of milk varies. Provided the conditions of manufacture are the same, such differences are due to differences in the composition of milk.

2. *Yield of cheese dependent upon certain constituents of milk.*—It has been shown that the yield of cheese depends most largely upon the two milk constituents, *fat* and *casein* (reference No. 3, p. 89).

3. *Milk solids divided into two classes.*—We may divide the solids of milk into two general classes: (1) Cheese-producing and (2) whey-producing. The former includes fat and casein; the latter albumin, sugar,

and soluble ash. This division is not strict, since a little fat and casein go into whey and a little albumin and sugar go into cheese. Most of the water of milk goes into whey (reference No. 3, p. 91). On an average 49.5 per cent of the milk solids goes into whey and 50.5 per cent into cheese.

4. *Amounts of milk fat and milk casein in different milks.*—Milk casein varies in amount in different milks, but not as much as fat does. The following table illustrates the relations of fat and milk casein in factory milks:

Fat in milk.	Milk casein in milk.	Fat in milk.	Milk casein in milk.
Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
3.00	2.10	4.00	2.50
3.25	2.20	4.25	2.60
3.50	2.30	4.50	2.70
3.75	2.40		

In general, when the fat in milk increases one-fourth of 1 per cent the milk casein increases one-tenth of 1 per cent (reference No. 3, p. 89). Question: If a normal milk contains 3 per cent of casein, how much fat should it contain?

5. *Increase of cheese yield with increase of fat in milk.*—Fat and casein of milk produce the solid portion of cheese. When fat increases in milk, casein increases also. Hence milk richer in fat produces larger yields of cheese (reference No. 3, p. 90). The yield of cheese from milk varies as the amount of fat and casein in milk vary.

Ratio of fat in milk to yield of cheese.

Fat in milk.	Cheese made from 100 pounds of milk.	Fat in milk.	Cheese made from 100 pounds of milk.
Per cent.	*Pounds.*	*Per cent.*	*Pounds.*
3.00	8.55	4.00	10.65
3.25	9.10	4.25	11.20
3.50	9.60	4.50	11.70
3.75	10.10		

As the milk grows richer in fat the same amount of milk makes more cheese. Question: How much cheese should be made from normal milk containing 5 per cent of fat? 5½? 6?

6. *Calculation of cheese yield from fat in milk.*—In average factory milk the approximate amount of green cheese from 100 pounds of milk can be found by multiplying the per cent of fat in milk by 2.7 (reference No. 6, p. 433); the amount of ripened cheese is found by multiplying by 2.6. Examples (see p. 19).

7. *Calculation of cheese yield from fat and casein in milk.*—A very close approximation to cheese yield from any given milk can be found when the amount of fat and of casein is known. Multiply the per

cent of fat in milk by 1.1 and the per cent of casein by 2.5; add the two products thus obtained (reference No. 5, p. 470).

8. *Losses of milk constituents in the manufacture of cheese.*—In 100 pounds of milk about 83 pounds of water go into whey and along with it most of the albumin and sugar and soluble ash. The losses of fat and casein require special consideration.

(*a*) *Loss of fat.*—The amount of fat lost in whey in cheese making varies from 0.20 to 0.50 and averages 0.33 pound of fat for 100 pounds of milk. The amount of fat lost is practically independent of the amount of fat in milk, as shown by the following table (reference No. 7, p. 214):

Fat in 100 pounds of milk.	Fat lost in whey for 100 pounds of milk.	Fat in milk lost in whey.	Fat in 100 pounds of milk.	Fat lost in whey for 100 pounds of milk.	Fat in milk lost in whey.
Pounds.	*Pound.*	*Per cent.*	*Pounds.*	*Pound.*	*Per cent.*
3.0 to 3.5	0.32	9.55	4.5 to 5.0	0.28	5.90
3.5 to 4.0	.33	8.33	5.0 to 5.25	.31	6.00
4.0 to 4.5	.32	7.70			

Examples under paragraph 6, page 18:

(1) How much green cheese can be made from 22,433 pounds of milk containing 4 per cent of fat? How much ripened cheese?

(2) If a cheese maker should make from 1,000 pounds of normal milk, testing 3½ per cent of fat, 75 pounds of cheese, how much cheese per pound of milk fat would there be? How would you account for such a yield of cheese?

Example under paragraph 7, page 18:

A sample of milk contains 4 per cent of fat and 2½ per cent of casein. How much green cheese should be made from 1,000 pounds of such milk?

Example under paragraph 8, above:

(1) A cheese maker makes into cheese 10,000 pounds of milk containing 3.7 per cent of fat. He produces 1,000 pounds of cheese containing 35 per cent of fat. (*a*) How many pounds of fat have been lost? (*b*) How much fat per 100 pounds of milk? (*c*) What percentage of fat in the milk is lost?

The old belief that all fat in milk over 3.5 per cent is inevitably lost in cheese making is fully disproved. The loss of fat in cheese making occurs mechanically. The fat globules on the cut surfaces of the curd are disengaged from these free surfaces and go into the whey. Following are some of the conditions that increase loss of fat in cheese making: (1) Any condition that interferes with complete coagulation by rennet, such as dilution with water, presence of preservatives like salt, formalin, etc. (2) Abnormal composition of milk, in which the casein is abnormally low in comparison with fat. (3) Jarring or stirring milk after rennet coagulation has commenced and before it is completed. (4) Cutting curd where too soft. (5) Violent, careless, and rapid motions of knife in cutting curd. (6) Heating curd too rapidly or to too high temperature. (7) Piling curd too much. (8) Putting curd to press too warm. (9) Too rapid application of pressure in hoop. (10) Fermentations that produce floating curds or excessive acidity or that dissolve any casein. Experiments bearing on these points will be given later in their appropriate connection.

(*b*) *Loss of casein in cheese making.*—The casein lost in cheese making is lost mostly in the form of fine particles of coagulated paracasein, which pass through the strainer when the whey is removed from the curd. This loss is not entirely avoidable, but is made greater by carelessness or violence in cutting curd and in subsequent handling, by agitation while drawing off whey, and by imperfect strainers. Any condition that interferes with the complete coagulation of the milk casein by rennet causes loss of casein. The average loss of casein in cheese making is 0.10 to 0.15 pound for 100 pounds of milk (reference No. 3, p. 92).

9. *Distribution of milk constituents of 100 pounds of milk in whey and cheese.*—The following table illustrates what becomes of the constituents of milk in the operation of cheese making:

		Water.	Milk solids.	Fat.	Casein.	Albumin.	Sugar, ash, and acid.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pound.*	*Pounds.*
Milk	100.00	87.00	13.00	4.00	2.50	0.75	5.75
Whey	89.35	83.00	6.35	.30	.10	.70	5.25
Cheese	10.65	4.00	6.65	3.70	2.40	.05	.50

10. *The relation of composition of milk to composition of cheese in the case of normal milk.*—Milk rich in fat as compared with milk poor in fat produces cheese containing more fat in proportion to water and paracasein compounds. The composition of cheese depends on the composition of milk, provided the cheese making is normally done. The following table illustrates these statements in the case of freshly made cheese:

Fat in milk.	Water in cheese.	Fat in cheese.	Paracasein compounds in cheese.	Fat in milk.	Water in cheese.	Fat in cheese.	Paracasein compounds in cheese.
Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
3.00	39.4	32.2	23.4	4.00	37.3	35.2	22.5
3.25	39.0	32.9	23.1	4.25	37.0	35.7	22.3
3.50	38.1	33.9	23.0	4.50	36.5	36.3	22.2
3.75	37.5	34.7	22.8				

11. *The relation of composition of milk to composition of cheese in the case of skimmed milk.*—The removal of fat from milk reduces the amount of fat in relation to casein, since only a little casein is removed with fat. The effect of skimming milk is illustrated in the case of milk

containing normally 4 per cent of fat and 2.50 per cent of casein (reference No. 3, p. 94).

	Pounds of fat removed from 100 pounds of milk.	Pounds of fat left in 100 pounds of milk.	Pounds of casein in milk.	Pounds of casein for 1 pound of fat.
Normal milk	0.00	4.00	2.50	0.63
Skimmed milk	.50	3.50	2.50	.71
Do	1.00	3.00	2.50	.83
Do	1.50	2.50	2.50	1.00
Do	2.00	2.00	2.50	1.25
Do	2.50	1.50	2.50	1.67
Do	3.00	1.00	2.50	2.50
Do	3.50	.50	2.50	5.00
Do	4.00	.00	2.50	.00

The figures below give the practical composition of green cheese made from normal and skim milks:

	Pounds of fat removed from 100 pounds of milk.	Pounds of fat left in 100 pounds of milk.	Per cent of fat in cheese.	Per cent of water in cheese.	Per cent of paracasein compounds in cheese.
Normal milk and cheese	0.00	4.00	37.3	35.2	22.5
Skim milk and cheese	1.00	3.00	31.4	37.4	26.2
Do	2.50	1.50	19.0	44.4	31.6
Do	3.50	.50	7.3	50.7	37.0

12. *The relation of composition of milk to composition of cheese in the case of milk containing added cream.*—Addition of cream to normal milk produces upon cheese the opposite effect from skimming—that is, increases the proportion of fat in cheese in relation to water and paracasein compounds (reference No. 3, p. 94).

13. *Standard of composition for whole-milk cheese.*—Cheese properly made from normal milk rarely, if ever, contains less than 32 per cent of fat. Of the total solids in cheese (fat, paracasein compounds, and ash) not less than 50 per cent should be fat (reference No. 3, p. 95).

14. *Composition of whey.*—The composition of whey varies according to the composition of the milk from which it comes and also according to conditions of cheese making. The following table illustrates extreme variations in cheese-factory whey:

	Average.	Highest.	Lowest.		Average.	Highest.	Lowest.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
Water	93.04	93.57	92.48	Albumin	0.72	0.90	0.45
Total solids	6.96	7.52	6.43	Sugar	4.00	4.50	3.50
Fat	.36	.55	.23	Lactic acid	.20	.25	.16
Casein	.10	.15	.05				

The amount of lactic acid in whey varies greatly, according to the time the determination of acidity is made. The acidity of whey when just removed from curd may vary from 0.10 to 0.15, and this will increase up to the end of the cheese-making process. Fresh whey shows less acid than the milk from which it comes, because the whey does not contain the calcium casein of the milk, this compound by itself showing an apparent acidity of 0.08 or 0.09 per cent.

15. *Composition of cheese.*—The following figures give the average composition of cheese when green and when ripened:

	In green cheese.	In ripened cheese.		In green cheese.	In ripened cheese.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Water	36.80	31.75	Paracasein, etc	23.75	25.50
Solids	63.20	68.25	Ash, acid, etc	5.70	6.00
Fat	33.75	36.75			

16. *The value of cheese as food.*—Cheese is one of our most concentrated and cheapest forms of food and furnishes a large amount of protein (reference No. 3, p. 98).

EXPERIMENT AND PRACTICE WORK, SECOND LECTURE.

Time required for experiments.—The actual work required in getting the experiments started may not occupy more than half an hour, if one determines solids in only one sample of milk and whey, but the work can not be completed until three or four hours later, when evaporation is complete. It will be well to make several different determinations either on the same or on different samples.

Apparatus required.—(1) Testing scale with set of metric weights weighing to 10 milligrams. (2) Small, flat-bottomed evaporating dishes 2½ or 3 inches in diameter. Small, granite-iron or tin dishes will answer. (3) An arrangement for heating these dishes directly over boiling water or live steam. A pail could be used provided with a close-fitting cover, in which are cut holes nearly as large in diameter as the small evaporating dishes used.

1. *Approximate determination of milk solids.*—Weigh a small granite-iron or bright tin basin, run in 10 cubic centimeters of milk and weigh again. (Weigh to within 10 milligrams.) Then heat the dish over live steam or boiling water for three or four hours. After wiping dry and cooling weigh again. Subtract the weight of the dish from the last weight, which gives weight of dried milk or milk solids. Divide this by weight of milk used. The result is the per cent of solids in milk. While the appliances used will not give accurate results, it is desirable to go through the work to know something of the method of determining solids.

ILLUSTRATION.

	Grams.
Weight of dish	101.55
Weight of milk and dish	111.25
Weight of milk used	10.30
Weight of dish and dried milk (solids)	102.85
Weight of dish and solids less weight of dish	102.85—101.55=1.30

Hence, 10.3 grams of milk contain 1.3 grams of solids.
1.3÷10.3=12.62 per cent of solids in milk.

2. *Determination of whey solids.*—Follow instructions given under preceding experiment, using, if possible, whey produced by same lot of milk used above.

ILLUSTRATION.

	Grams.
Weight of dish	101.55
Weight of whey and dish	111.83
Weight of whey used	10.28
Weight of dish and dried whey (solids)	102.20
Weight of dish and solids less weight of dish	102.20—101.55=0.65

0.65÷10.28=6.32 per cent of solids in whey.

3. *To determine per cent of cheese solids in milk.*—Subtract per cent of whey solids from per cent of milk solids.

ILLUSTRATION.

	Per cent.
Milk solids	12.62
Whey solids	6.32
Cheese solids	6.30

THIRD LECTURE.

CARE OF MILK TO BE USED IN CHEESE MAKING.

1. *Necessity of clean milk.*—One of the fundamental conditions of successful cheese making is clean milk. Milk may appear to be in good condition when being made into cheese, but may contain organisms that develop later in and spoil the cheese.

2. *Sources of contamination.*—Assuming that milk is in every way normal as it leaves the udder of the cow, it may later become unfit for cheese making by the presence of bad odors and tastes, resulting from (1) food eaten, (2) flavors absorbed, and (3) bacterial infection. Other conditions apart from bad flavors, such as souring, make milk unfit for Cheddar cheese making.

3. *Flavors from foods eaten.*—Certain foods that have strong taste and odor impart to milk their characteristic flavors. Most common among these are onions, garlic, turnips, cabbages, ragweed, etc. (references No. 3, p. 25; No. 8, p. 13, and No. 9, p. 61).

4. *Absorption of flavors by milk.*—Milk, particularly if warm, absorbs odors present in the surrounding air. The most common sources of such odors are the manure in unclean stables and any strongly fla-

vored food present in the stable during milking, such as silage (references No. 3, p. 25; No. 8, p. 13, and No. 10, p. 104).

5. *Injurious flavors from bacterial infection.*—The most common source of milk contamination is from bacteria. These get into the milk ducts of the udder and contaminate the first milk drawn (references No. 9, p. 36, and No. 11, p. 39). After the milk is drawn bacteria get into it (1) from the cow (references No. 9, p. 44, and No. 11, p. 41); (2) from the air (references No. 9, p. 43, and No. 11, p. 45); (3) from the milk vessels (references No. 9, p. 44, and No. 11, p. 34), and (4) from the milkers (references No. 3, p. 24; No. 9, p. 44, and No. 11, p. 41).

6. *Characteristics of bacteria.*—Bacteria are very small, colorless plants, invisible to the unaided eye. They are extremely numerous and widely distributed in soil, air, and water. In shape they are spherical, rod-shaped, and spiral (references No. 9, p. 20, and No. 11, p. 2). They multiply by simple division with great rapidity (references No. 9, p. 26, and No. 11, p. 4). Bacteria require as food compounds containing nitrogen, carbon, hydrogen, oxygen, and inorganic matter (references No. 9, p. 28, and No. 11, p. 7). The sugar, casein, and albumin in milk and its products furnish available food for bacteria. Bacteria grow only within certain ranges of temperature, the most favorable temperatures being between 80° and 95° F. for those common in milk (references No. 9, p. 29, and No. 11, p. 8). All bacteria are destroyed at the temperature of boiling water (reference No. 9, p. 29) and by many chemical substances called antiseptics (reference No. 11, p. 18). Bacteria are always associated with filth, absence of sunlight, and impure air.

7. *Obtaining clean milk.*—Milk produced for use in cheese making should be kept fairly free from bacteria, and the rapid growth of those in the milk should be retarded. The number of bacteria in milk can be largely reduced by the following precautions: (1) Every condition in and about the stable should be regulated with reference to an abundant supply of pure air, a direct exposure to sunlight, and the absence of dust or any form of dirt. No manure or stagnant water should be near the barn. The barnyard should be distant from the milking stall (reference No. 9, p. 48). (2) Keep the body of the cow as free as possible from every form of dirt, dust, and loose hairs (reference No. 9, p. 47). (3) Before milking, the cow's udder should be properly cleaned and the milker should have clean hands and clothing (reference No. 9, p. 44). (4) The milk vessels must be kept bacteriologically clean (reference No. 9, p. 44). The water used in washing vessels should be free from unhealthful contaminations (reference No. 9, p. 51). (5) Milk pails should be used offering the least exposure of surface of milk (reference No. 9, p. 52). (6) After milking a pailful remove the milk from the barn

to a clean dry room, strain carefully, and cool to 60° F., if possible, to prevent too rapid growth of bacteria. The aeration of milk before cooling should be done, if at all, only in air comparatively free from bacteria and never in the stable (reference No. 9, p. 55). After the milk has been cooled to 60° F. it should be covered to prevent evaporation and consequent thickening of layer of cream (reference No. 8, p. 17).

8. *Cleanliness in cheese factory.*—Cleanliness in a cheese factory is just as important as in the barn. Good milk can not be made into good cheese in a dirty factory. The inside and outside of weighing can, cheese vats, etc., must be kept strictly clean. The floors must be scrubbed thoroughly (reference No. 8, p. 19). Sal soda is in many cases a cheap substitute for soap, not only dissolving grease, but neutralizing acids and loosening dirt. Everything possible must be done to prevent any accumulation of dirt in corners. All cloth materials used must be thoroughly boiled at frequent intervals. All drains should be kept disinfected (reference No. 8, p. 20).

EXPERIMENT AND PRACTICE WORK, THIRD LECTURE.

Time required for experiments.—Four hours at least will probably be required to get the work started and much more will be needed to become at all skillful.

Apparatus required.—(1) 1 cubic centimeter pipettes inclosed in glass tubes for sterilizing; (2) small flasks marked to hold 99 cubic centimeters; (3) small homeopathic vials, some marked to hold 19 and some 5 cubic centimeters; (4) absorbent cotton; (5) peptone-agar culture medium; (6) Petri dishes, and (7) test tubes.

1. *General outline of method used in determining the number of germs in milk.*—The method of finding out how many bacteria are present in milk is based upon placing a small amount of milk upon a sterile substance which will enable the bacteria to grow. After 24 to 36 hours small spots appear and their number is greater or less according to the number of bacteria in the milk (references No. 9, pp. 251–266, and No. 11, p. 32).

2. *Sterilizing milk.*—Determine the acidity of some milk and put some in a half dozen test tubes and plug the tubes with absorbent cotton. Then place in boiling water thirty minutes. Let them stand at room temperature. At the end of four days determine the degree of acidity in tube No. 1; at the end of eight days determine the acidity in No. 2, and continue examining at intervals of four days until all have been examined. Do not remove the cotton plug from any tube until you are ready to examine at once.

Sterilize a portion of some milk and then allow sterilized and unsterilized portions to stand uncovered at room temperature. Examine each day and notice when each coagulates.

3. *Showing relative number of bacteria in different milks.*—(Reference No. 9, p. 252, etc.)

(*a*) Sterilize all apparatus used in an oven at a temperature of 300° to 350° F. for an hour.

(*b*) Culture medium had better be prepared in advance by some one familiar with methods (reference No. 9, pp. 253–257), as it will hardly be practicable for each student to acquire proper training in the short time allowed for the work.

(*c*) Put some water in the flasks marked to hold 99 cubic centimeters, sterilize by steaming two hours, and cool. Then to this add 1 cubic centimeter of the milk to be examined and shake thoroughly (reference No. 9, p. 258).

(*d*) Melt the agar culture contained ready for use in a test tube by placing the tube in warm water. Then add 1 cubic centimeter of the diluted milk to the agar culture in the test tube, shake thoroughly, but gently. Then pour the contents into a Petri dish (reference No. 9, pp. 258, 259), put cover on dish, and set aside at a temperature of 70° to 80° F.

(*e*) Examine Petri dishes containing milk and agar culture daily for four or five days. Notice the number of spots (reference No. 9, p. 260).

4. *Examine in the manner indicated above milk* obtained in the following manner: (1) Milk from an uncleaned cow kept in a dirty, dusty stable, and (2) milk from a cow carefully cleaned before milking and milked in a clean place free from dust.

FOURTH LECTURE.

THE USE OF THE BABCOCK METHOD OF TESTING MILK IN CONNECTION WITH THE MAKING OF CHEESE.

1. *What the Babcock test is.*—The Babcock test is a method for determining the amount of fat in milk and its products. The test is based on the action of strong sulphuric acid upon the solids of milk other than fat, by which the milk fat is released from the restraining influence of the other compounds and so is free to collect in one separate mass, centrifugal force being employed to complete the separation.

2. *Advantages of test.*—The Babcock test possesses the following advantages: (1) Inexpensiveness, (2) accuracy, (3) rapidity, (4) ease and simplicity, (5) direct results, (6) applicable at once to many samples, (7) results easily confirmed, and (8) applicable not only to milk, but to products (reference No. 3, p. 100).

3. *Disadvantages of test.*—(1) Acid used is dangerous to handle and so requires caution, (2) strength of acid must be examined and kept uniform, (3) speed of centrifugal must be properly regulated, (4) temperature of milk must be under control, (5) graduated glassware may be incorrect, and (6) every detail must be carefully performed (reference No. 3, p. 101).

4. *Opportunities for use in cheese making.*—The Babcock test finds occasion for use in cheese making as follows: (1) Testing milk of individual patrons when the dividends are made on the basis of the milk fat, (2) testing milk to ascertain if it has been seriously skimmed, (3) testing milk to use fat as a basis for estimating yield of cheese and regulating amount of salt used, (4) testing whey and press drippings to ascertain if fat loss is excessive, and (5) testing cheese for amount of fat.

5. *Apparatus and materials used in testing milk.*—The following list includes the apparatus and materials used in testing milk: (1) Test bottles, graduated from 0 to 10 per cent, so that each division represents two-tenths of 1 per cent when 17.5 cubic centimeters (18 grams) of milk are used; (2) pipette for measuring milk, holding 17.6 cubic centimeters to mark; (3) measure for acid, holding 17.5 cubic centimeters to mark; (4) centrifugal machine, having a wheel 12 to 20 inches in diameter, easily capable of being run at a speed of 700 to 1,200 revolutions a minute, and (5) commercial sulphuric acid having a specific gravity above 1.82 and below 1.83, preferably just 1.825. [The lecturer should have all the apparatus and materials at hand and explain each in full detail.] (Reference No. 3, p. 101, or No. 12, pp. 34–54.)

6. *Sampling milk for testing.*—Milk that has soured and thickened or on the surface of which cream has risen and dried somewhat, or milk the fat of which has partially churned, is difficult to sample; but these difficulties should not be common in cheese-factory work. The samples to be tested must be thoroughly mixed (reference No. 3, p. 103, or No. 12, p. 26).

7. *Composite samples.*—In order to avoid testing milk daily, composite samples may be prepared and tested for a week or ten days. Much care should be used in preparing and keeping composite samples (reference No. 3, p. 110, or No. 12, p. 134). For use of milk thief in taking composite samples, see reference No. 8, p. 29.

8. *Performing test.*—Following are the steps to be followed in testing milk: (1) Running sample of milk into test bottle (reference No. 3, p. 104, or No. 12, p. 28). (2) Adding acid to milk in test bottle (reference No. 3, p. 104, or No. 12, p. 28). (3) Mixing milk and acid (reference No. 3, p. 105, or No. 12, p. 30). (4) Whirling test bottles and adding water (reference No. 3, p. 105, or No. 12, p. 31). (5) Measuring fat (reference No. 3, p. 106, or No. 12, p. 32). [The lecturer should perform and explain every operation in detail, making clear the reasons for each step. He should then require each student to go through and explain each detail until an independent degree of skill has been attained.]

9. *Testing whey by Babcock method.*—The test is conducted in the usual way, but special bottles having small necks should be used (reference No. 3, p. 108, or No. 12, p. 74).

10. *Determining fat in cheese by Babcock method.*—The method is less satisfactory, owing to difficulty of sampling cheese. It is necessary to weigh the cheese, using about 5 grams. Then add 15 cubic centimeters of hot water and shake to an emulsion. Then add acid and proceed as before. The per cent of fat read on bottle must be multiplied by 18 and divided by the number of grams of cheese used (reference No. 3, p. 109, or No. 12, p. 77).

EXPERIMENT AND PRACTICE WORK, FOURTH LECTURE.

Time required.—One's first test can probably be made in twenty minutes, but the details should be often repeated so that one can acquire rapidity and accuracy. It would be well to devote two hours the first day to the test and then use the test afterwards every day as opportunity offers.

Apparatus and materials required.—See paragraph 5, preceding. In addition, 1 "N-H" milk-bottle tester.

1. *Use of pipette.*—Practice drawing milk into pipette and bringing to mark until it can be done quickly and accurately (reference No. 12, p. 27).

2. *Running milk into test bottle from pipette.*—After filling pipette properly run milk into test bottle, so that milk will all be delivered without running over (reference No. 3, p. 104, or No. 12, p. 128).

3. *Measuring acid and pouring into test bottle.*—(Reference No. 3, p. 104, or No. 12, p. 28.) Practice pouring acid into bottle so that it will run down side of bottle and form a layer under the milk without mixing with it. *In handling sulphuric acid be careful not to get it on the skin or clothing.*

4. *Mixing milk and acid.*—(Reference No. 3, p. 105, or No. 12, p. 30.) Practice giving the bottles the peculiar kind of rotary motion that mixes the milk and acid without throwing any out of the bottle.

5. *Whirling test bottles and adding water.*—(Reference No. 3, p. 105, or No. 12, p. 31.) Observe carefully precautions as to rapidity of revolution. Determine number of revolutions made per minute (reference No. 12, p. 50) in relation to number of turns of handle.

6. *Measuring fat.*—Practice reading fat in graduated neck (reference No. 3, p. 106, or No. 12, p. 32).

7. *Measuring accuracy of test bottles.*—Use brass plunger milk-bottle tester according to directions given with the apparatus.

8. *Testing other substances than milk for fat.*—After acquiring facility in making tests with milk test skim milk, whey, butter, and cheese (reference No. 3, pp. 108, 109, or No. 12, pp. 74–77).

FIFTH LECTURE.

OTHER TESTS USED IN CONNECTION WITH CHEESE MAKING.

In addition to determining fat there are some other forms of tests of value in connection with cheese making, and some of these will be considered here.

1. *Use of lactometer in determining solids of milk.*—The specific gravity of milk is the weight of a given bulk of milk as compared with the weight of an equal bulk of water at the same temperature. The specific gravity of milk averages about 1.032. Fat, being lighter than water, decreases specific gravity, while such compounds as casein and milk sugar, being heavier than water, increase the specific gravity (reference No. 3, p. 113). The specific gravity is found out by means of a lactometer. Two forms are in common use, the Quevenne lactometer (reference No. 3, p. 43) and the board of health lactometer (reference No. 3, p. 114). The lactometer is used as follows in determining solids of milk: Rule 1. To find the per cent of total solids in milk multiply the per cent of fat by 1.2 and add the result to one-fourth of the lactometer (Quevenne) reading (reference No. 3, p. 114). [Examples should be given and actual determinations should be made by the lecturer and then by each student.]

2. *Testing acidity of milk and whey.*—The method of testing acidity in milk or whey is based upon the chemical action taking place between acids and alkalis (reference No. 3, p. 111). Acids and alkalis neutralize each other and form compounds called salts, which are neither acid nor alkaline, but neutral. An indicator is a substance used to tell whether a solution is acid, alkaline, or neutral. The most common indicator is phenolphthalein, which turns pink in alkali solutions and colorless in acid or neutral solutions. For use, 1 gram of phenolphthalein is dissolved in 50 cubic centimeters of strong alcohol and 50 cubic centimeters of water. Only a few drops need be used (reference No. 3, p. 111). The two forms of acid test in common use are those devised by Mann and by Farrington.

(*a*) Mann's acid test (reference No. 3, p. 112, or No. 12, p. 96). Measure just 50 cubic centimeters of milk or whey into a clean porcelain cup or glass. Add a few drops of phenolphthalein and then let in from a burette, previously filled to zero point, a little neutralizer. A pink color appears and then disappears on stirring. Add a little more neutralizer and stir. Continue this until the pink color remains even after considerable stirring. Look at burette and see how many cubic centimeters of alkali have been used. Suppose 10 cubic centimeters of "neutralizer" have been used to neutralize the milk or whey, then multiply 10 by .018 and the result is 0.18, which is the per cent of lactic acid in the milk or whey.

(*b*) Farrington's alkaline tablet test. In this form of test the alkali and indicator (phenolphthalein) are mixed together in the form of solid tablets. One tablet is dissolved so as to make 100 cubic centimeters of solution, which is added in small amounts to 17.6 cubic centimeters of milk or whey until the pink color remains. Each cubic centimeter of solution used stands for 0.01 per cent of lactic acid. Thus a milk using 15 cubic centimeters of alkali solution contains 0.15 per cent of acid (reference No. 3, p. 112, or No. 12, p. 99). Some precautions must be used about keeping tablets dry until used, and solutions a day old should not be used.

[Suggestions to lecturer: Make sure that the relation of acids and alkalis and the use of indicators are understood by the student. Perform the test (one or both), explaining each step, using milk from fresh to sour and also whey from fresh to a day old. Also have each student make several tests, so as to become familiar and accurate in the manipulation. Impress the necessity of using exact quantities.]

3. *Methods of testing rennet extracts.*—The rennet test is a method for ascertaining in what time a definite amount of rennet extract will coagulate a certain amount of milk at a given temperature. It is of value for learning the strength of rennet extract and the ripeness of milk. Two forms are in common use—(1) the Monrad test, and (2) the Marschall test.

(*a*) The Monrad rennet test (reference No. 3, p. 67, or No. 8, p. 38). The conditions used in this test are as follows: Amount of milk used, 160 cubic centimeters; temperature of milk, 82° to 86° F.; amount of rennet, one-half of 1 cubic centimeter diluted with 5 cubic centimeters of water. The diluted rennet is added to the milk at the fixed temperature, stirred in, and the time noted by the second hand of a watch. The time is again noted when the milk has coagulated. The more quickly the coagulation takes place the stronger the rennet. Precautions to be used in comparing rennet extracts: (1) Use the same milk if possible, (2) and the same degree of temperature. Special apparatus for this can be purchased.

(*b*) The Marschall test (reference No. 3, p. 68, or No. 8, p. 39). In this test the same general rules of procedure apply, but the coagulation takes place in a cup having on its sides graduated lines and in the bottom a glass tube with a very small bore. After the rennet is added the glass tube is opened and the milk allowed to trickle out until it coagulates and ceases to run. The marks made inside the cup show how much milk has run out. The stronger the action of the rennet the more quickly the milk coagulates, the less runs out, and the fewer spaces are uncovered. One disadvantage of the test is that the bore of the glass tube differs in different cups, which makes difference in results. In trying different cups for comparison, always use the same sample of milk. The Marschall test is convenient for ordinary factory work, but it is not capable of so great delicacy as the Monrad test.

[Suggestion to lecturer: Have apparatus for both of these tests. Perform tests before students and then have each student perform the tests. Use milks of different age in the test. Have different students compare results on the same sample of milk.]

4. *Detection of injurious ferments in milk.*—The "Wisconsin curd test" is a method for detecting milks that are undesirable for cheese making (reference No. 3, p. 64, or No. 8, p. 15). The test consists in making a small chunk of cheese curd from milk in a glass jar. Pint fruit jars with small holes in the covers are sterilized in boiling water and then nearly filled with the milks to be tested and placed in water at 95° to 100° F. Ten drops of rennet are added to each jar and mixed. After curdling, the curd is cut into small pieces and stirred, the whey being poured off from time to time until the curd mats. The curd is then kept at about 95° F. for six or eight hours and then examined. Injurious forms of ferments in milk are indicated when the curd is spongy in texture and very full of holes or "mushy" in texture or offensive to smell. This test is of value in detecting individual herds and even individual cows, whose milk is not good for cheese making.

[Suggestions to lecturer: This test should be performed on different milks, some of which have been treated so as to be made bad. Each student should be required to perform the details until they are familiar. Every milk used in cheese making by the students should be examined by this test, and it should be applied at times to the milk of each herd.]

5. *The hot-iron test.*—(References No. 3, p. 74, and No. 8, p. 61.) The hot-iron test is a means of measuring roughly the amount of paracasein that has been formed from calcium paracasein or of the amount of acid that has been formed and combined with calcium of calcium paracasein. It does not indicate the amount of acid present in the whey. The test is made as follows: A small mass of curd is pressed in the hand to remove the whey and is then pressed against a bar of iron heated a little short of redness and then drawn away carefully. Fine silky strings adhere to the iron, the length depending mainly on the amount of free paracasein present in the curd. Samples of pure paracasein may be drawn out in strings a foot or more long when tested by the hot iron. Uncombined casein behaves the same way (reference No. 1, pp. 16, 28).

EXPERIMENT AND PRACTICE WORK, FIFTH LECTURE.

Time required.—Four hours can well be devoted to work on the different tests described, getting familiar with details, so that one can apply them daily in regular work.

Apparatus and materials required.—(1) Quevenne lacto-thermometer, (2) New York State Board of Health lacto-thermometer, (3) glass cylinder or jar 11 inches by 2 inches, (4) Mann's acid test outfit, (5) Farrington's alkaline tablet test outfit, (6) Wisconsin curd test outfit, and (7) rennet extract.

1. *Use of lactometer.*—(Reference No. 3, pp. 113–114, or No. 12, pp. 80–93.) Use both Quevenne and New York State forms of lactometers. The lacto-thermometer forms are preferable. (1) Test lactometers in water at different temperatures. (2) Do the same in milk and whey. (3) Calculate per cent of total solids in different samples of milk from lactometer reading and per cent of fat. Calculate per cent of solids-not-fat.

2. *Action of acids and alkalis on each other.*—Add 1 cubic centimeter of sulphuric acid to 100 cubic centimeters of water and mix by shaking. Then dissolve 5 alkaline tablets in 85 cubic centimeters of water. Take 20 cubic centimeters of the dilute sulphuric acid in a teacup and add to it 5 drops of solution of phenolphthalein. Then add the alkali solution gradually, shaking after each addition and continuing until the pink color remains instead of disappearing on shaking. Then add 1 cubic centimeter of dilute acid and note the disappearance of color. Add more alkali until color reappears. What chemical change takes place when the alkali is added to the acid? Does the acid combine with the alkali? Is the acid all combined with acid when the pink color appears? Do acids form color with phenolphthalein? Do alkalis form color with phenolphthalein? (Reference No. 3, p. 111.)

3. *Mann's acid test.*—(Reference No. 3, p. 112, or No. 12, p. 96.) Carry out details of Mann's acid test with (a) milk, (b) whey, examing them at intervals of an hour.

4. *Farrington's alkaline tablet test.*—(Reference No. 3, p. 112, or No. 12, p. 99.) Use this test in same manner as preceding.

5. *Monrad rennet test.*—(Reference No. 3, p. 67, or No. 8, p. 38.) Apply the test as described to the same milk at intervals of thirty minutes for two or three hours, letting milk stand at temperature of 80° to 85° F.

6. *Marschall rennet test.*—(Reference No. 3, p. 68, or No. 8, p. 39.) Apply to same milk at intervals of thirty minutes, letting milk stand at temperature of 80° to 85° F.

7. *Wisconsin curd test.*—(Reference No. 3, p. 64, or No. 8, p. 15.) Apply this test to milk of different herds of cows, noticing whether there is any relation between the results and the cleanliness of the stables in the case of the individual herds.

8. *Hot-iron test.*—Prepare cheese curd with rennet and test from time to time on hot iron (references No. 3, p. 74, and No. 8, p. 61).

SIXTH LECTURE.

THE RELATION OF BACTERIA AND ENZYMS TO CHEESE MAKING.

1. *Bacteria needed for cheese making.*—For the successful making of Cheddar cheese lactic-acid bacteria are necessary (reference No. 9, p. 248). There are many varieties of these bacteria, but they are alike in being able to convert milk sugar into lactic acid. The acid of milk is noticeable to the taste when it reaches 0.3 per cent. The milk begins to thicken when the acid reaches 0.4 per cent, and above 0.5 per cent the curd becomes solid. The chemical action of the lactic acid is given in Lecture 1, paragraph 3. Less than one-half of 1 per cent of milk sugar is required to furnish the lactic acid needed in making cheese. The most favorable temperature for growth of the bacteria is 90 to 95° F. (references No. 3, p. 26, and No. 9, p. 64). The lactic-acid bacteria are of value by preventing the growth of injurious forms of fermentation.

[Suggestions to lecturer: Have each student determine the amount of acid (see Lecture 5, paragraph 2) in fresh milk, and then at hourly intervals at room temperature for six or eight hours.]

2. *Bacteria undesirable for cheese making.*—Among bacterial ferments that act injuriously in cheese making are the following: (1) Those producing gas abundantly, and thereby causing "floating" curds and "huffing" cheese (references No. 9, p. 69, and No. 11, p. 169); (2) those digesting the curd; (3) those producing offensive flavors (reference No. 11, p. 177); and (4) those producing poisonous products (reference No. 11, p. 179). Many injurious fermentations can be detected. (See Lecture 5, paragraph 4.)

3. *Two classes of ferments.*—Two classes of ferments are recognized: (1) Organized and (2) unorganized. Organized ferments are living organisms capable of producing fermentations, such as bacteria (reference No. 3, p. 22). An unorganized ferment or enzym is a chemical substance or ferment without life, capable of causing many changes, the enzym itself undergoing little or no change. They are produced by bacteria and in higher forms of plants and animals. There are two enzyms of special interest in cheese making: (1) Rennet enzyms and (2) galactase.

4. *Rennet enzym* is an unorganized ferment capable of coagulating the calcium casein of milk. On account of this property rennet is a fundamental substance in Cheddar cheese making. Rennet is used in the form of an extract.

(*a*) Source of rennet extract. The usual source is the fourth stomach of a suckling calf. The enzym may be extracted by treatment with dilute salt water. Reliable commercial rennet extracts are preferable to home-made extracts, being of more uniform strength. Rennet should be kept in a cool, dark place (references No. 8, p. 32, and

No. 3, p. 65). For method of testing strength of rennet extracts, see Lecture 5, paragraph 3. The enzym contained in rennet extract is essentially the same as pepsin.

(*b*) Strength of rennet to coagulate milk. One part of good commercial rennet extract, which is only a dilute form of rennet enzym, readily coagulates five thousand parts of milk (reference No. 3, p. 66).

(*c*) Chemical action of rennet. When rennet coagulates the calcium casein of milk it forms a substance called calcium paracasein, which is in general properties about like calcium casein. Cheese curd is an impure form of calcium paracasein. This is quite different from the solid substance formed by calcium casein when treated with acids.

5. *Conditions of rennet action.*—The conditions of rennet action should be carefully studied in an experimental way.

(*a*) Acids affect action of rennet. Milk must be neutral or acid for coagulating action of rennet. Rennet will not coagulate milk having an alkaline reaction. Increased amounts of acid increase the rapidity and completeness of coagulation (reference No. 3, p. 66, or No. 8, p. 40).

(*b*) Temperature affects time of coagulation by rennet. The quickness of coagulation increases with increase of temperature (reference No. 3, p. 66, or No. 8, p. 41). The character of coagulated substance is soft and loose when coagulation takes place below 60° F. or above 120° F. At 77° to 110° F. the curd is firm and solid. Heating rennet above 120° F. weakens its coagulating power.

(*c*) Strength and amount of rennet extract. Strength of rennet extract, as well as increased amounts of rennet, increases the rapidity and completeness of coagulation (references No. 3, p. 66, and No. 8, p. 42). Dilution of milk by water decreases rapidity of rennet action.

(*d*) Action of rennet is affected by different chemical compounds added to milk. Rennet coagulation is delayed by common salt, formalin, borax, and other substances (references No. 3, p. 67, and No. 8, p. 43).

(*e*) Effect of heating milk upon rennet action. When milk is heated above 150° F. for some time it coagulates less quickly than unheated milk. Boiled milk coagulates slowly or not at all. Coagulation may be restored by addition of acid (reference No. 3, p. 67).

(*f*) The relation of soluble lime (calcium) salts to rennet coagulation. Rennet will not coagulate milk when soluble lime salts are not present. Rennet coagulation occurs in two stages: (1) Rennet changes calcium casein into calcium paracasein, but no coagulation takes place; (2) coagulation occurs in the presence of soluble lime salts (reference No. 1, p. 23).

The action of acid in hastening rennet action is explained by the increased formation of soluble lime salts. Boiling milk lessens the amount of soluble lime salts, and so interferes with action of rennet.

Addition of acid to boiled milk makes lime salts soluble again and restores power of rennet coagulation.

(*g*) Milk from different cows of the same herd coagulates with rennet in quite varying periods of time (reference No. 3, p. 67).

6. *Galactase* is an enzym existing naturally in milk. It has the power of coagulating and then dissolving milk casein. Galactase resembles pepsin, but appears to be much slower in its action (references No. 1, p. 161; No. 13, p. 77; and No. 14, p. 157).

EXPERIMENT AND PRACTICE WORK, SIXTH LECTURE.

Time required for experiments.—Four hours or more can be advantageously given to the following experiments:

Apparatus required.—(1) Monrad's or Marschall's rennet test; (2) rennet extract; (3) aseptic scale pepsin, 1-3000; (4) dilute sulphuric acid; (5) sodium carbonate; (6) salt; (7) calcium chlorid, and (8) thermometer.

1. *Effect of acids on rennet coagulation of milk.*—Take 2 or 3 quarts of milk, test acidity (see Lecture 5, paragraph 2), then determine rapidity of coagulation by the rennet test (Lecture 5, paragraph 3). Record results. To 1 pint of the remaining milk add 10 cubic centimeters of dilute sulphuric acid made by adding 1 cubic centimeter of sulphuric acid, such as is used in Babcock test, to 100 cubic centimeters of water. Test acidity of milk again and make rennet test again. Increase amount of acid in the milk by adding 20 cubic centimeters more. Again test acidity and make rennet test. Compare results. Then add 20 cubic centimeters more of dilute acid and make acid and rennet tests again.

2. *Effect of alkali on coagulation of milk by rennet.*—Add to 1 pint of milk 1 gram of sodium carbonate and add rennet in usual amount. If it coagulates, note the time required.

3. *Effect of letting milk stand on rennet coagulation.*—Make acid and rennet tests of a sample of milk. Put milk in warm place (80° to 90° F.) and repeat acid and rennet tests at intervals of a half hour for four or five hours or more. Keep careful record of all tests.

4. *Effect of temperature on rennet coagulation.*—Make rennet test of some milk at 84° F. Then make tests at following temperatures and note results: 60° F., 70° F., 75° F., 80° F., 90° F., 100° F., 110° F., 120° F., and 140° F.

5. *Effect of heat on coagulating power of rennet.*—Heat some rennet extract to 140° F. for fifteen minutes and then test its coagulating power.

6. *Effect of amount of rennet upon coagulation of milk.*—Perform the rennet test upon portions of the same milk, using (a) 5, (b) 10, (c) 15, (d) 20, and (e) 25 cubic centimeters of rennet extract. Note and compare the results.

7. *Effect of dilution by water upon coagulating power of rennet.*—Make a rennet test of some milk. Dilute portions of this milk as follows: (a) One part of water and four parts of milk; (b) one part of water and three parts of milk; (c) one part of water and two parts of milk; and (d) one part of water and one part of milk. Make rennet test of each of diluted samples and compare results.

8. *Effect of salt upon coagulating power of rennet.*—Make rennet test of samples of milk. Then to the same milk add salt in amounts equal to 1, 2, 3, 4, and 5 per cent of the milk by weight. Make rennet test of each of these salted samples and compare results. Try similar experiments with common borax.

9. *Effect of heating milk upon rennet coagulation.*—Make rennet test of some milk. Heat one portion of milk at 160° F. for twenty minutes and another portion to boiling for fifteen minutes. Then make rennet tests again. To some of the boiled milk add a few drops of dilute acid and repeat the rennet test.

10. *Effect of soluble calcium salts on action of rennet.*—Make rennet test of a sample of milk. Add 1 cubic centimeter of a 10 per cent solution of calicum chlorid to the milk and repeat.

11. *Effect of calcium salts on rennet coagulation of heated milk.*—Heat a portion of same milk used in experiment 10 to boiling for ten or fifteen minutes. Cool and make rennet test. To another portion add dilute calcium chlorid and make rennet test.

12. *Variation of rennet coagulation in milk of different cows.*—Make rennet test on separate milk of each cow of some available herd.

13. *Compare rennet extract with 1-3000 aseptic scale pepsin,* using the pepsin at the rate of one-half gram per 100 pounds of milk (reference No. 8, pp. 34, 53).

SEVENTH LECTURE.

PRELIMINARY STEPS IN MAKING CHEDDAR CHEESE.

Outline of different steps of operation of cheese making.

1. System of keeping records of the operations of cheese making.
2. First care of milk at the factory.
3. Ripening the milk.
4. Adding color.
5. Coagulating the milk by rennet ("setting" the milk).
6. Cutting the curd.
7. Heating the curd.
8. Removing the whey from the curd.
9. Cheddaring the curd.
10. Milling the curd
11. Salting and pressing curd.
12. Curing cheese.

1. *System of keeping records of the operations of cheese making.*—It is desirable for all cheese makers to keep daily records of the details of

their work for constant reference, and it is absolutely necessary that students keep such records faithfully from the start. Below we give the details of such a record:

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1. Vat used (number of vat).
2. Condition of milk (tainted, clean, etc.).
3. Amount of milk in vat............pounds.
4. Fat in milk............per cent.
5. Ripeness of milk by—
    1. Monrad rennet test............seconds.
    2. Marschall rennet test............spaces.
    3. Acid test............per cent of acid.
6. Kind of starter used.
7. Amount of starter used............pounds.
8. Time when starter was added............a. m. p. m.
9. Temperature of milk when rennet was added............degrees F.
10. Ripeness of milk when rennet was added—
    1. By rennet test............seconds or spaces.
    2. By acid test............per cent.
11. Time when rennet was added............a. m. p. m.
12. Amount of rennet (or pepsin) used............ounces or grams.
13. Amount of rennet (or pepsin) used per 1,000 pounds of milk....ounces or grams.
14. Time when curd was cut............a. m. p. m.
15. Time in coagulating............minutes.
16. Condition of curd when cut (hard, soft, etc.)
17. Time when heating began............a. m. p. m.
18. Acid test of whey when heating began............per cent.
19. Temperature to which milk was heated after cutting, etc............degrees F.
20. Time at which temperature was reached............a. m. p. m.
21. Test when whey was drawn—
    1. By hot-iron test............inches.
    2. By acid test............per cent.
22. Time at which whey was drawn............a. m. p. m.
23. Time from cutting curd to drawing whey............a. m. p. m.
24. Amount of fat in whey............per cent.
25. Condition of curd (sweet, tainted, solid, gassy, floating, etc.).
26. Time when curd was ground............a. m. p. m.
27. Length of string on hot iron when curd was ground............inches.
28. Acid test of whey drippings when curd was ground............per cent.
29. Time when curd was salted............a. m. p. m.
30. Acid test of whey running from curd just before salting............per cent.
31. Amount of salt used for 1,000 pounds of milk............pounds.
32. Time when curd was put in press............a. m. p. m.
33. Temperature of curd when put in press............degrees F.
34. Kind of cheese made.
35. Number of cheeses made.
36. Time when cheese was dressed............a. m. p. m.
37. Time when cheese was pressed............a. m. p. m.
38. Weight of green cheese............pounds.
39. Average amount of milk per pound of cheese............pounds.
40. Amount of cheese from 100 pounds of milk............pounds.
41. Amount of cheese made from 1 pound of milk fat............pounds.

Special remarks.—(Include here any deviations from the usual modes of procedure not included in the foregoing list.)

2. *First care of milk at the factory.*—While the milk is accumulating in the vat, it should be stirred frequently up to time of setting in order to keep the cream from separating. When the vat is full enough, the amount of milk present being figured, the acidity of the milk is determined or a rennet test made. If, as usually happens, the milk is sweet, heat to 84° to 86° F. and ripen (reference No. 8, p. 49).

3. *Ripening milk.*—(References No. 3, p. 68, and No. 8, p. 49.) This consists in the formation of a certain amount of lactic acid. Its object is to control more completely the operations of cheese making. Lactic acid may be formed by allowing milk to stand a while at a temperature of 84° to 86° F. When lactic-acid bacteria are not present abundantly or are kept back in growth by injurious organisms, it is necessary to use a "starter."

4. *Preparation of starter.*—(References No. 3, p. 43, and No. 8, p. 50.) A starter is a material containing large numbers of lactic-acid organisms added to milk or cream for the purpose of causing lactic fermentation. Starters are of two kinds—(1) natural and (2) pure culture (references No. 8, p. 51, and No. 9, pp. 197, 199.) A natural starter may be prepared as follows: Milk of the best possible character, taken under precautions necessary to insure cleanliness, is heated to 90° F. and then kept at 65° to 70° F. In twenty-four hours this is ready for use. Some of this starter may be used in preparing a starter for the following day, putting a little into some skim milk that has been heated to 180° F. for thirty minutes and then cooled to 70° F. and allowed to stand twenty-four hours. The starter may thus be propagated from day to day. A new starter should be prepared as soon as any unfavorable quality is noticed. Pure-culture starters are special preparations consisting of certain selected organisms known to be adapted to forming lactic acid. Several such are on the market and give good results (reference No. 8, p. 51). Starters should not be prepared from the milk mixed in the vat or from whey (reference No. 8, p. 48).

5. *Use of starter in cheese making.*—In using a starter reject the upper portion and pass the rest into the milk through a fine strainer. The amount to be used depends upon the acidity or ripeness of the milk at the start, but will vary from 2 to 5 pounds for each 100 pounds of milk (reference No. 3, p. 69). Experience must serve as a guide to some extent.

6. *How to ascertain the proper degree of ripeness.*—Since ripeness in milk is the same as acidity, the ripeness can be measured (1) by determining the acidity, as described in Lecture 5, paragraph 19, or (2) by making a rennet test. The general aim is to have such an amount of acid formed when the rennet is added that the curd will remain in the whey not more than two and three-quarters to three hours. This result is usually accomplished when the acid test shows 0.19 to 0.21

per cent of acid or when the milk coagulates by the Monrad test in forty-five to sixty seconds or by the Marschall test in two and one-half spaces. Milk containing as much as 0.2 per cent of lactic acid when delivered at the factory is overripe and liable to cause trouble (references No. 3, p. 69, and No. 8, p. 48).

7. *Adding color.*—When coloring matter is used, it should be added just before the rennet is, being diluted before addition and thoroughly mixed into the mass of milk (reference No. 8, p. 52). The amount used depends upon the special demand of the market.

8. *Preparation and addition of rennet.*—Adding rennet is commonly known as "setting milk with rennet." The milk is heated gradually to 84° to 86° F., with constant stirring and tested for ripeness. If ripe enough, rennet is added at once. If not ripe enough, it is allowed to stand until it gives the right test, a starter being used or not, as circumstances require. When the milk is ripe enough, the rennet extract is added. In this connection three points must be considered—(1) temperature of milk, (2) amount of rennet added, and (3) method of adding extract.

(*a*) Temperature of milk. Different makers use for setting milk different temperatures varying from 82° to 86° F. The higher temperature saves time by hastening ripening, especially when no starter is used. At temperatures much above 86° F. the curd hardens too quickly to handle conveniently, and there is danger later of loss of fat (references No. 3, p. 70, and No. 8, p. 52).

(*b*) Amount of rennet extract to use. This will depend on the strength of the extract, other things being equal. Use enough to coagulate the milk in fifteen to twenty minutes for a quick-curing cheese and in thirty to forty minutes for a slow-curing cheese. The extract commonly used is added at the rate of 2½ to 5 ounces for 1,000 pounds of milk.

(*c*) Method of adding rennet extract. Before being added to milk the rennet should be diluted with twenty to forty times its volume of water to prevent uneven action in the milk. The milk should be thoroughly stirred just before the rennet is added. Then after the addition of the rennet the milk is at once stirred again gently, but thoroughly, and continued for some minutes. Then the surface is stirred quietly to keep cream from rising, but is stopped before there is any sign of coagulation. The surface is then covered with cloth to hold temperature and the milk kept undisturbed until coagulation is complete (references No. 3, p. 71, and No. 8, p. 53).

[Suggestions to lecturer: Each student should receive special practice under supervision in each of the manipulations described. Practice in ripening milk can at first be obtained with small amounts of milk. The preparation and use of starters must receive most careful attention in practice. In working with larger quantities of milk the lecturer can direct and supervise the work closely and gradually leave the students a greater degree of independence as they show a proper comprehension and power of manipulation.]

9. *Use of pepsin in place of rennet in cheese making.*—(Reference No. 8, p. 53.) Rennet extracts are practically impure and dilute forms of pepsin. In place of rennet extract one can use pepsin at the rate of 5 grams for 1,000 pounds of milk. The pepsin is dissolved in any convenient amount of water before addition to milk. Only *scale pepsin* should be used. The pepsin solution should be made up daily in just the amount needed for the day.

EXPERIMENT AND PRACTICE WORK, SEVENTH LECTURE.

Time required.—Two hours or more can be easily given to the work outlined below.

Apparatus, etc., required.—(1) Pails, arrangements for heating, small vats, thermometers; (2) rennet extract, pepsin; (3) skim milk, 10 to 20 pounds or more for each worker; (4) whole milk, 100 pounds or more, and (5) rennet test and acid test.

1. *Preparation of starter.*—Prepare starter according to directions given.

2. Ripen 10 or 20 pounds of milk in a pail with and without using a starter. Apply rennet test and also determine degree of acidity.

After the milk has ripened properly add rennet.

Compare pepsin and rennet.

When some familiarity has been acquired in handling small amounts of milk, then perform the work with 100 pounds or more of skim milk and later with whole milk.

EIGHTH LECTURE.

CUTTING AND HEATING CURD.

1. *Purpose of cutting curd.*—The object of cutting curd is to allow the whey to go out of the paracasein. This is more rapid and complete in proportion as the pieces of curd are smaller (reference No. 3, p. 71).

2. *When to cut curd.*—Curd cut too soft results in large losses of fat and smaller yield of cheese. Curd that is too hard before cutting loses whey less easily and results in poor quality of cheese. Hence curd must be cut at right stage of hardness. The stage for cutting is ascertained in this way: The end of index finger is inserted obliquely into curd half an inch or more and then slowly raised to surface. If the curd breaks apart with a clean fracture without leaving small bits of curd on the finger and if the whey in the broken surface is clear and not milky, the curd is ready to cut (references No. 3, p. 72, and No. 8, p. 53).

3. *How to cut curd.*—In cutting curd uniformity in size of pieces of curd must be the object. Two knives of special design are used in cutting curd. One is the horizontal knife with numerous parallel blades; the other, the perpendicular. Makers differ somewhat in their way of using these knives. The following directions should be followed: (1) Use horizontal knife first. (2) Insert carefully into curd at one end of vat. (3) Do not jam or smash the curd in inserting knife. (4) Move the horizontal knife quietly and firmly from end to end of the vat until it has passed through the whole mass of curd. (5) Then use perpendicular knife at once. (6) Cut not only lengthwise the vat, but also crosswise. (7) Toward the end of cutting move the knife somewhat more rapidly. In overripe milk the curd should be cut into smaller pieces. The fineness is governed largely by the number of times the knives pass through the curd (reference No. 8, p. 55).

4. *Effect of fineness or coarseness of curd.*—Cutting curd fine has the effect of releasing the whey more rapidly and completely and results in a cheese containing less moisture. Coarse cutting causes the slower escape of whey and produces cheese with a higher moisture content.

5. *Stirring curd after cutting.*—The curd if allowed will settle to the bottom of the vat after cutting and mass together again, thus preventing the proper escape of the whey. To prevent this massing the curd must be kept in motion, very gentle at first, while the curd is soft. The curd must be kept from settling in the corners of the vat or sticking to sides. The whey should be clear and quite free from particles of floating curd (references No. 3, p. 73, and No. 8, p. 57). The curd contracts and hardens on surface during stirring, so that pieces do not stick together so easily. The hardening retards escape of whey, and heat must be used to keep whey from going out of curd.

6. *When to apply heat.*—The heating or "cooking," improperly so called, should begin as soon as the pieces of curd contract and harden on the surface. The cause of the shrinkage is probably due in part to the action of lactic acid upon the calcium paracasein of the curd, the calcium being combined with the lactic acid in forming free paracasein, a compound that has the property of contracting. Heat favors the formation of acid, and its action upon the calcium paracasein of the curd. The heat should be applied gradually and the stirring continued constantly. Under normal conditions the heat is applied so as to raise the temperature of the curd and whey 1° F. in five minutes and rarely more than 2°. The heating should be somewhat slower up to 90° F. than above that point, because the shrinking of curd and expulsion of whey take place less rapidly below than above 90° F. The heating should be carried up to 98° F. The curd becomes less tender as the temperature increases and toward the last can be stirred very vigorously without harm. When 98° F. has been reached, the

curd is allowed to settle on the bottom of the vat with only an occasional stirring until a certain amount of free paracasein is formed by the action of more lactic acid (references No. 3, p. 73, and No. 8, p. 57). There are special forms of apparatus that may be used in stirring curd (reference book No. 8, p. 59).

7. *Acidity of whey in regulating heating.*—If the first whey contains about 0.11 per cent of acid, the acid will form slowly and the curd should be heated more gradually. If the whey contains 0.13 or 0.14 per cent of acid, the curd can be heated more rapidly.

[Suggestions to lecturer: In the first stages of cheese making there is needed great care in developing an acute sense of observation, not only of sight but of touch. These can be acquired only by actual experience under the guidance of a trained teacher. In the condition of curd at time of cutting and in the gradual changes of pieces of curd from very soft to tough condition there is opportunity for the very closest training in observation.]

EXPERIMENT AND PRACTICE WORK, EIGHTH LECTURE.

Time required.—Two to four hours should be given to the work.

Apparatus required.—The apparatus is the same as for the preceding lecture and in addition curd knives.

1. Go through operation of cheese making from start either with 10 or 20 pounds of milk in a pail or with 100 pounds or more in a small vat. Make special study of indications that tell when to cut curd.

2. The use of curd knives can be learned only by use in a vat. Practice using the knives carefully according to directions of instructor.

3. Stir curd after cutting with care, and constantly study the appearance of the curd in order to learn when to apply heat.

4. Apply heat according to directions, watching the changes that take place in the curd.

NINTH LECTURE.

REMOVING WHEY FROM CURD AND CHEDDARING THE CURD.

1. *When to remove whey from curd.*—The whey should be removed from curd when lactic acid has caused the formation of certain amount of free paracasein or when there is "enough acid on the curd," as the cheese maker commonly says (reference No. 3, p. 73, or No. 8, p. 61). The whey should be removed very promptly when the time comes and the curd thoroughly drained.

2. *How to ascertain when there is acid enough.*—Several indications show when the whey should be removed from the curd. (1) The pieces of curd should be contracted to less than one-half their original size. (2) They should be firm and rubber like, so that when a mass of curd is pressed between the hands and then suddenly freed from pressure the pieces should fall apart at once and show no tendency to

stick together. (3) The curd should show strings one-eighth of an inch long on the hot iron by the test described in Lecture 5, paragraph 5. (4) Instead of the hot-iron test the amount of acid in the whey may be used, which should be about 0.01 per cent less than at the time of setting. Thus, if the acidity of the milk was 0.19 per cent at the time of setting, the acidity of the whey should be about 0.18 per cent when the whey is removed from the curd.

3. *Changes caused in curd by formation of acid.*—(Reference book No. 13, p. 36.) The curd formed by rennet from milk is an impure form of calcium (lime) paracasein. When lactic acid is formed in the curd and whey it gradually unites with the calcium, forming free (not combined with calcium) paracasein and calcium lactate. It is this free paracasein that draws out in silky threads on a hot iron. It is free paracasein also that imparts to cheese curd its peculiar plastic or "matting" properties. The formation of free paracasein is the main object of forming acid in cheese making.

4. *Effect of excessive and incomplete heating ("cooking").*—A curd that is heated too high or too long produces a cheese with too little moisture, resulting in a "corky" texture. Heating at too low a temperature or for an insufficient length of time results in producing cheese containing too much moisture and showing a pasty, soft body. Such cheese sours easily.

5. *Cheddaring the curd.*—This operation is the distinctive feature of the cheddar method of cheese making. It consists, essentially, in allowing the curd to mat or pack together in solid chunks after removal of whey. The operation may take place (1) directly on the bottom of the vat or (2) on curd racks placed in the bottom of the vat, or (3) it may be removed to a curd sink (reference No. 3, p. 74, or No. 8, p. 67).

6. *Matting curd on vat bottom.*—After the whey is drawn off the curd is piled up along the two sides of the vat with an open channel between to facilitate the running off of the whey that drains from the curd. When pieces of curd have matted together, forming a solid mass, it is cut into blocks about 8 by 8 by 12 inches, which are turned over. After some draining the blocks are piled two deep, each time the upper part being turned down. Later the blocks are piled in deeper piles. The repiling is repeated again and again, always exposing to the air the portions that were turned inside on the previous piling in order to keep the heat uniform through the mass (references No. 3, p. 74, and No. 8, p. 64). Curd racks and curd sinks are frequently convenient in facilitating draining (references No. 3, p. 75, and No. 8, p. 64).

7. *Effects of cheddaring curd.*—Cheddaring curd effects two results: Expulsion and draining of whey from curd, and (2) formation of free paracasein as a result of the union of lactic acid with the calcium

of calcium paracasein (reference No. 1, p. 36). As a result of the changing of most of the calcium paracasein into uncombined paracasein the physical condition of the curd changes from a tough, rubber-like consistency with a high water content to a mass having a smooth, velvety appearance and feeling, and a softer, somewhat plastic consistency. The texture also changes so that the curd acquires a peculiar fibrous condition or grain, tearing off somewhat like the cooked meat of the chicken's breast. Along with these changes the curd forms longer strings on a hot iron, usually an inch or more after the cheddaring has continued some time.

8. *Influence of cheddaring upon quality of cheese.*—Extended piling of curd tends to make a quick-curing, soft cheese. If a slow-curing cheese is desired, the curd should be piled little or none at all, the blocks being simply turned over and over in a single layer. Curd from very ripe milk should be piled little (reference No. 8, p. 69).

9. *When the cheddaring process is complete.*—The cheddaring process is regarded as complete when we have the following conditions: (1) The curd forms strings on hot iron an inch or more in length. (2) The whey running from the curd shows an acidity of 0.7 to 0.8 per cent. (3) The curd should be velvety in appearance and feeling and tear apart like the breast meat of a chicken.

EXPERIMENT AND PRACTICE WORK, NINTH LECTURE.

Time required.—Since it is necessary to begin with the operation of cheese making each day, additional time will be required each day, but this will serve to review preceding stages.

Apparatus, etc., required.—Same as before. Small amounts of milk can be used in pails or a larger amount in a vat. The instructor will have to be governed by circumstances as to the detailed methods he employs.

1. Start in operation of cheese making and make special study of indications that tell when to remove curd, such as the appearance and feeling of the curd, test on hot iron, and acidity of whey. Apply all these tests carefully.

2. At proper time remove whey and proceed to the operation of cheddaring the curd. Study with care the changes that the curd goes through.

3. Make various tests for completion of process, such as hot iron, acidity of whey, and texture and appearance of curd.

TENTH LECTURE.

MILLING, SALTING, AND PRESSING CURD.

1. *Milling curd.*—(References No. 3, p. 76, and No. 8, p. 69.) When the cheddaring process is complete as determined by the tests given in the last paragraph of the preceding lecture the curd is ready

for milling. The time for milling should come about halfway between removing the whey and salting the curd. By this process the curd is cut into small pieces in order to salt it more uniformly and handle it more easily. Several machines are sold for this purpose. The best machines cut the curd into pieces of uniform size without tearing it.

2. *Treatment of curd after milling.*—After milling, the curd is piled up in order to flatten out the pin holes and stirred enough to keep it from matting together. The softening of the curd, which is the result of the formation of more uncombined paracasein, continues after milling as the result of further formation of lactic acid. The curd should be kept warm all the time (references No. 3, p. 76, and No. 8, p. 77).

3. *When to salt curd.*—The curd is ready for salting when (1) the hot-iron test shows strings 2 inches long, or (2) the whey running directly from the curd shows an acidity of 1 per cent in normal cases or 1.1 to 1.2 per cent in case of gassy or weak-bodied curds.

4. *Amount and kind of salt to use.*—The amount of salt used is usually at the rate of 2½ to 3 pounds for 1,000 pounds of milk. A moist curd should be salted more. A salt of fairly coarse grain is preferable, because it dissolves more slowly and penetrates the curd more fully. When the salt is added, the curd is spread out thin, cooled to 90° F. Then the salt is mixed evenly through the curd and the curd stirred until the salt dissolves completely.

5. *Effects of salting.*—While salt is added for the sake of flavor, it produces other effects, such as (1) aiding in removing whey, (2) hardening the curd, checking or retarding the formation of lactic acid. An unsalted cheese cures more rapidly and is apt to develop a better flavor, the intensity increasing with increase of curing temperature. Excessive salting makes a cheese mealy, because too dry, and cures slowly (reference No. 16, p. 157). Much of the salt added passes into the whey. Green cheese normally salted contains 0.6 to 1 per cent of salt, and this increases somewhat in the cured cheese through loss of moisture (reference No. 16, p. 147).

6. *Temperature of curd when put in press.*—Before pressing, the curd should be cooled to a temperature between 78° and 84° F. If pressed at higher temperatures, fat is lost and the pieces of curd do not stick together perfectly. If pressed at lower temperatures, the pieces fail to form a solid mass by cementing properly (reference No. 3, p. 76, or No. 8, p. 81).

7. *Object of pressing curd.*—The main object of pressing curd is to give the cheese a definite form for market and not alone to squeeze out whey, which should be removed mostly while the curd is in the vat.

8. *Preparing hoop for receiving curd.*—A round cap cloth of the size of the hoop is placed at the bottom and soaked in hot water. The bandage is then placed in the hoop, turning the edge in evenly about an inch and a half on the bottom. Curd is then placed in the hoop,

using about the same amount of curd in each hoop, but being careful not to fill hoop too full (reference No. 8, p. 83). The top cap cloth is then put on and the fibrous ring placed about edge and then the follower on top.

9. *Pressing curd.*—When the curd is put in press in normal condition, a moderate pressure will cause the pieces of curd to cement together in a smooth solid mass. The pressure should be uniform and continuous for twenty-four hours. With a screw press the pressure is applied gradually at first, full pressure reached in about fifteen minutes, and is tightened as fast as the screws become loose, especially during the first hour (reference No. 8, p. 84).

10. *Dressing cheese.*—When the curd has been in press about one hour it is well compacted and is then taken out. The bandage is freed from wrinkles and trimmed evenly, so that it will come over the end of the cheese about an inch and a half. Put it in position and soak it with hot water; then wring out the cap in hot water and place it on the end of the cheese (reference No. 8, p. 85). Return to press and apply full pressure.

[The mechanical manipulations involved in preparing the hoop and dressing the cheese can be properly learned only from actual practice, and the foregoing outline must be filled in by the students under the fuller directions of the lecturer.]

For a description of presses, bandages, hoops, etc., see reference No. 8, pp. 81–85.

11. *Troubles common in cheese making.*—Temperature conditions during cheese making favor growth of many kinds of bacteria, and sometimes undesirable forms prevail, producing abnormal behavior in curd and defective cheese. Two of the most familiar conditions are gas-forming fermentations and overripe milk.

12. *Gas-forming fermentations.*—Some fermentations produce gas in the curd, causing it to swell, filling it with small holes and making it very spongy. The result of such conditions is a "floating" or "gassy" curd. This condition is due to lack of cleanliness on the part of one or more patrons. Such milk can be detected by the curd test (see Lecture 5, paragraph 4). When suspected, the results of these fermentations can be prevented or lessened by abundant use of a starter, developing in the curd abundance of lactic acid, which is more or less poisonous to the gas-forming bacteria. The milk is well ripened before adding rennet, and the curd heated somewhat more rapidly than usual and from 2° to 6° higher. The escape of gas from curd is favored by keeping warm and frequent repiling. Gas fermentations often produce offensive smells in the curd, and these may be largely washed out by drenching the curd with warm water (105° F.). However, it is difficult to make perfect cheese without some loss of yield from such milk. The ideal method is prevention by cleanliness (references No. 3, p. 77, and No. 8, p. 66).

13. *Overripe milk.*—In hot weather milk may be on the verge of souring when ready to be made into cheese. Under such conditions the changes occur more rapidly than usual; the curd "works too fast." The whey does not escape fast enough. This may be helped by stirring curd constantly and thoroughly after removing whey. No starter should be used in an overripe milk; more rennet should be added to the milk and at a lower temperature. After cutting, the curd is stirred until the whey separates well before raising temperature (references No. 3, p. 78, and No. 8, p. 58).

EXPERIMENT AND PRACTICE WORK, TENTH LECTURE.

Time required.—The work at this point carries one through the whole operation of cheese making and will use five to seven hours or more a day.

Apparatus, etc., required.—Same as before, with curd mill, salt, cheese press, bandage, etc.

Start operations of cheese making from beginning. Mill the curd when the indications are right. Then pile and stir occasionally, keeping it warm all the time. Study the changes in curd.

Salt the curd at time shown by hot-iron test and by acid test.

Observe temperature when curd is put to press.

The instructor must give personal illustrations of method of preparing press, pressing, dressing cheese, etc.

After the details of the entire operation of cheese making have been fairly well mastered, then the students can undertake such of the following experiments as they may have time for:

(1) Make cheese from 100 pounds or more each of (a) milk skimmed by separator, (b) normal milk containing 3 to 3.5 per cent of fat, and (c) normal milk containing 4 to 4.5 per cent of fat. Note the following points: (1) The weight of cheese in each case, (2) the per cent of fat in whey in the case of b and c, and (3) the commercial quality of the cheese when one and two months old.

(2) Make cheese from 100 pounds or more of normal milk and from the same amount of milk to which has been added 25 per cent of water. Compare results in yield, loss of fat in whey, etc.

(3) Make cheese from two portions of the same milk. Run one portion in a normal manner and the other portion in the same way, except to stir the milk after it has begun to coagulate with rennet. Notice the appearance of the whey in both cases, and also the per cent of fat in whey and the yield of cheese.

(4) Compare results in respect to per cent of fat in whey and yield of cheese when curd is cut (a) hard, (b) medium, (c) soft, (d) coarse, (e) fine, (f) carefully, (g) carelessly.

(5) Compare results in respect to per cent of fat in whey, yield and quality of cheese when (a) the curd is heated ("cooked") too quickly, (b) too slowly, (c) too high, (d) too low.

(6) Compare results in respect to per cent of fat in whey, yield and quality of cheese when (a) the curd is put to press too warm, (b) too cold.

(7) Make into cheese milk containing 0.2 to 0.25 per cent of acid and study the behavior of the curd, the per cent of fat in whey, and the quality and yield of cheese.

(8) Make cheese with use of rennet at the rate of 3, 6, and 9 ounces per 1,000 pounds of milk. Compare results in working, in behavior of curd, and in quality of cheese at thirty and sixty days.

(9) Salt cheese at rate of 2, 4, and 6 pounds of salt per 1,000 pounds of milk. Note the yield of cheese and the quality at thirty, sixty, and ninety days.

(10) Make cheese from 100 pounds or more of (a) normal milk containing 3.5 to 4.5 per cent of fat and (b) from skim milk made from the same amount of the same milk after it has had its fat removed by being run through a separator. Compare the yields of cheese.

ELEVENTH LECTURE.

CARE OF CHEESE AFTER MANUFACTURE.

Importance of care of cheese after being made has been overlooked. The best made cheese can be easily ruined by lack of care after removing from press. Few cheese factories have proper facilities for curing cheese in the best way. Under the old system much emphasis was placed on greasing cheese, using caps, and making great efforts to prevent mold, but little effort was made to reduce loss of moisture.

1. *Changes caused by curing cheese.*—Cheese must have age before it is salable for consumption. Several different changes take place during curing period, among which are (1) loss of moisture and (2) changes in paracasein.

2. *Loss of moisture in curing cheese.*—(Reference No. 17, p. 281.) Cheese begins to lose weight as soon as it is taken from press, and the loss continues some months. The rapidity and extent of loss of moisture vary with several conditions, such as (1) the percentage of moisture present in green cheese, (2) texture of cheese, (3) size and shape of cheese, (4) temperature of curing room, (5) moisture in air of curing room. The more moist a cheese when first made the more rapidly it loses moisture. Cheese with spongy texture loses moisture more rapidly than cheese with perfect texture. Large cheeses lose moisture less rapidly in proportion to their weight than smaller cheeses. "Flats" lose weight more rapidly than cheeses of the same diameter and twice the height. The higher the temperature of the curing room the greater the loss of moisture. The greater the moisture in the air of the curing room the smaller is the loss of weight.

3. *Changes in paracasein.*—In freshly coagulated cheese curd the calcium casein of milk is changed to calcium paracasein, which, under

the action of lactic acid, is changed during the process of cheese making into free paracasein (not combined with calcium). Fresh cheese, aside from the fat and moisture, consists largely of this uncombined paracasein. This compound undergoes the changes in ripening which profoundly affect the whole character of the cheese. Green cheese is tough, somewhat rubber-like, not appreciably soluble on the tongue, difficult of digestion, and lacking in flavor. In the course of ripening it becomes softer, more easily digestible, and acquires characteristic flavors. The exact causes of these changes are not known fully, but they are due in part to rennet, in part to galactase, and in part to bacterial action, either direct or through their enzyms. Flavor is not formed by either rennet or galactase (reference No. 3, p. 80). These changes are influenced in extent and rapidity by temperature, moisture, amount of rennet and salt used in making cheese, and amount of acid present (reference No. 16, p. 156).

4. *Influence of temperature upon quality of cheese.*—Cheese cures more quickly at higher temperatures, but at the expense of flavor and texture. Cheese cured at 75° F. or above loses fat by leakage. Cheddar cheese cured above 60° F. does not give the best quality. Cheese cures more slowly at lower temperatures but the product is superior in quality. Also less moisture is lost at lower temperatures. Best results are secured by curing cheese below 40° F. for a period of six months or more (references No. 18, p. 54, and No. 19, p. 110).

5. *Covering cheese with paraffin.*—Loss of moisture in cheese can be largely prevented by coating the cheese with a thin layer of paraffin without injuring the quality (reference No. 18, p. 82, or No. 19, p. 111). At higher temperatures the saving is greater and the quality is better than in cheese not so treated. Another distinct advantage of using paraffin is that it prevents cheese becoming moldy. Conveniences for coating cheese with paraffin can be obtained from dairy-supply houses. The cheese should be allowed to dry out well on the surface and then dipped in melted paraffin that is at a temperature of 150° to 200° F., using paraffin that has a melting point not above 120° F. From three days to a week should be enough to dry out the surface of the cheese before coating.

6. *Moisture in air of curing rooms.*—(Reference No. 3, p. 81, or No. 8, p. 100.) The relative amount of moisture in the air can be determined by a hygrometer. For curing Cheddar cheese the moisture should be 65 to 75 per cent of saturation.

7. *Control of moisture and temperature in curing rooms.*—If a cheese maker cures his own cheese properly he should have a special curing room, properly made and equipped. The curing room should be on the coolest side of the building with the least possible outside exposure. Details for construction are given in Wisconsin Experiment Station Bulletin 70. The control of moisture and temperature are secured

through (1) ventilation by air forced through horizontal subearth ducts or deep vertical subearth wells and ducts; (2) ventilation over ice; or (3) evaporation of water (reference No. 20 or No. 3, p. 81).

8. *Method of procedure in the absence of curing rooms.*—Where it is impossible to have proper curing rooms the best results can be realized by coating the cheeses with paraffin and turning them over to the buyer at once, or the factory may arrange to place them in some convenient cold storage.

EXPERIMENT AND PRACTICE WORK, ELEVENTH LECTURE.

In a course of cheese instruction like the one contemplated by this course of study it will hardly be practicable to undertake any experiment or practice work in cheese making. The most that can be done is for the lecturer to arrange to have on hand for illustration cheeses that have been cured at different temperatures and with and without paraffin covering.

TWELFTH LECTURE.

COMMERCIAL QUALITIES OF CHEDDAR CHEESE AND METHODS OF JUDGING CHEESE.

1. *Qualities of cheese.*—Certain qualities of American Cheddar cheese have been adopted as a basis of the commercial value of one cheese as compared with another. The terms commonly used in expressing these qualities are the following: (1) Flavor, (2) body, (3) texture, (4) color, (5) general appearance, and (6) salt. The number of terms used varies in different market centers.

2. *Score cards.*—As a matter of convenience and uniformity, score cards are often used. The following is a typical illustration of a score card:

Cheese judging numerical and descriptive score card.

Score for cheese (or sample) marked ——.

NUMERICAL SCORE.

	Perfection.	Score.
	Points.	*Points.*
Flavor	45	....
Texture	20	....
Body	15	....
Color	10	....
Appearance and salt	10	....
Total	100	....

Date..................190 . Initials or number of judge..............................

DESCRIPTIVE SCORE.

[Check qualities below as they apply to cheese examined.]

Flavor.	Texture.	Body.	Color.	Appearance.	Salt.
Perfect.	Perfect.	Perfect.	Perfect.	Perfect.	Perfect.
Clean.	Close.	Solid or firm.	Straight.	Edges square.	Too little.
High or quick.	Loose or porous.	Smooth.	Translucent.	Rind smooth.	Too much.
Low or flat.	Mechanical holes.	Silky.	White specks.	Cracks.	
Too much acid.	Gas or pin holes.	Waxy.	Streaked.	Light spots.	
Too little acid.	Swiss holes.	Pasty or salvy.	Wavy.	Neat.	
Sour		Stiff, corky, or curdy.	Mottled.	Slovenly.	
Sweet or fruity.		Weak.	Acid cut.		
Tainted.		Mealy.	Too high.		
Weedy.		Gritty.	Too light.		
Barnlike.		Watery.	Uncolored.		
Strong.		Dry.			
Tallowy.					

3. *Flavor of cheese.*—By flavor, as applied to cheese, we mean the odor of the cheese, or really odor and taste combined. The sense of smell is generally more sensitive in detecting most variations of flavor in cheese than taste. The flavor of cheese is ascertained by crushing a piece in the palm of the hand to warm it up slightly and is at once held under the nose.

(*a*) "Perfect" flavor in Cheddar cheese resembles that of first-class butter, with an added something of its own that can not be easily described. Cheese flavor is sometimes described as "nutty." Perfect cheese flavor is not strong and is free from all traces of an objectionable character. The taste should be mild and somewhat lasting, but not so sharp as to "bite" the tongue.

(*b*) "Clean" flavor is entirely free from objectionable smell.

(*c*) "High" or "quick" flavor is a delicate flavor that disappears quickly.

(*d*) "Low" or "flat" flavor indicates only traces or absence of flavor, or insipidity.

(*e*) "Too much acid" applies to flavor that smells somewhat sour, but does not taste sour.

(*f*) "Too little acid" applies to flavor that is rather mild and lacking in character.

(*g*) "Sour" cheese tastes sour when fresh, from containing too much whey.

(*h*) "Sweet" or "fruity" flavor is suggestive of pineapple odor and is somewhat sickish.

(*i*) "Tainted" flavor describes a variety of mildly or strongly offensive odors.

(*j*) "Weedy" flavor applies to flavor coming from food eaten by cow, such as leeks, ragweed, cabbage, etc.

(*k*) "Barnlike" flavor is self-descriptive, suggesting odor of manure.

(*l*) "Strong" flavor is very pronounced, but free from anything offensive; it is a good flavor strongly developed.

(*m*) "Tallowy" flavor resembles that of tallow.

4. *Texture of cheese.*—Texture, as applied to cheese, refers mainly to compactness. Commonly the body is considered as a part of texture, but the two qualities are easily distinct.

(*a*) "Perfect" texture in cheese is indicated when a cut surface of the inside of the cheese presents to the eye a solid, compact, continuous appearance, free from breaks, holes, and chunks. A plug drawn from a cheese of perfect texture should be smooth and not "fuzzy." When a plug is broken in two it should not crumble, but show a flaky appearance, termed a "flinty" break, resembling the surface of broken cast iron or broken flint.

(*b*) "Close" texture describes the appearance of a cut surface of cheese when free from all kinds of holes.

(*c*) "Loose" or "porous" texture is indicated by lack of compactness and solidity.

(*d*) "Mechanical holes" in cheese are irregular, open spaces caused by incomplete cementing together of the curd particles in the press.

(*e*) "Gas" or "pin holes" are small holes.

(*f*) "Swiss" holes are fairly large, round holes, such as are present in Emmenthaler cheese.

5. *Body of cheese.*—This term, used in connection with cheese, refers to the character of the substance or consistence of cheese. This quality is ascertained by pressing a piece of cheese between the thumb and fingers.

(*a*) "Perfect" body in a cheese is indicated when the cheese is solid, firm, and smooth in substance or consistence.

(*b*) "Solid" or "firm" bodied cheese shows a certain amount of resistance under pressure, somewhat like a piece of fat pork or cold butter.

(*c*) "Smooth" bodied cheese when pressed between the thumb and fingers feels smooth and velvet-like, as distinct from harsh, gritty, or mealy.

(*d*) "Silky" bodied cheese is smooth, but not over solid.

(*e*) "Waxy" bodied cheese is much the same as silky, but possessing more firmness or solidity.

(*f*) "Pasty" or "salvy" cheese is very soft, usually from an excess of moisture. It sticks to the fingers when pressed.

(*g*) "Stiff" or "corky" or "curdy" bodied cheese is hard, overfirm, and tough, and does not crush down readily when pressed in the hand.

(*h*) "Weak" bodied cheese is very soft, lacking in firmness, but not necessarily sticky.

(*i*) "Mealy" bodied cheese is cheese that breaks down in fine crumbs when pressed.

(*j*) "Gritty" bodied cheese feels harsh and gritty under pressure.

(*k*) "Watery" bodied cheese is excessively soft and pasty.

(*l*) "Dry" bodied cheese is generally very mealy or hard.

6. *Color of cheese.*—Whether artificially colored or not cheese may vary considerably in color.

(*a*) "Perfect" color in cheese is indicated by evenness of color throughout the mass of cheese. The cheese should be somewhat translucent.

(*b*) "Straight" color is even color throughout the entire mass of cheese.

(*c*) "Translucent" color applies to cheese which appears slightly translucent when the plug is held between the eye and the light.

(*d*) "White specks" is a term that explains itself. Such specks are a defect.

(*e*) "Streaked" color indicates that there are lighter portions of cheese in the form of streaks.

(*f*) "Wavy" color applies to lighter portions appearing in waves.

(*g*) "Mottled" color in cheese shows in light spots of fairly large size.

(*h*) "Acid cut" color is shown in cheese when considerable portions of the cheese have been made lighter in color by the presence of too much acid.

(*i*) "Too high" color is indicated by a reddish color, caused by using too much coloring matter. However, this question of color is a relative one, because the demand in different markets varies from uncolored to extremely high color.

(*j*) "Too light" color is usually used with reference to cheese that has been made uniformly dead white by the action of too much acid.

(*k*) "Uncolored" Cheddar cheese is not white, but of a light amber shade.

7. *Appearance of cheese.*—The term "appearance" refers to the general appearance of the cheese to the eye in respect to neatness and uniformity.

"Perfect." In a cheese of perfect appearance the curd must be smooth, even in color, free from cracks, and fairly hard. The bandage must be without wrinkle and neatly rounded over the edges about an inch and a half on each end of the cheese. The sides of the cheese should be straight and of uniform height all around.

The faults of appearance are as follows, the terms being self-descriptive: (1) Cracks, (2) light spots, (3) roughness in rind, (4) uneven edges, (5) wrinkles in bandage, (6) lack of uniformity in ends and in height, and (7) bulging out at sides or ends.

8. *Salt in cheese.*—The salt in cheese is "perfect" when just enough has been used to impart a sufficient taste to the cheese. "Too little" salt results in injury to flavor and texture, causing bitterness of flavor and porous texture. "Too much" salt results in a dry, mealy texture and imperfect flavor.

EXPERIMENT AND PRACTICE WORK, TWELFTH LECTURE.

Time required.—A half hour or less a day for several days will give more effective results in judging cheese than to devote more time continuously in one day.

Apparatus required.—A cheese trier.

1. The use of a cheese trier in taking a sample plug from a cheese should be learned first.

2. Have a score card ready. The examination of cheese for flavor is tried by direct smelling of plug and by warming some of the cheese in the hand. In each cheese examined let each one indicate what flavor or flavors he perceives and give it a numerical score. The examination for texture, body, color, appearance, and salt is carried on similarly, each one keeping a careful record describing each quality and also giving each a numerical value. After the examination of one cheese is completed it will be well for the instructor to go over the whole work in detail, pointing out any errors in judgment that may appear on the different score cards. Let every point be fully explained. Then pass on to another cheese. It is desirable, of course, to have as much variety as possible in the cheeses examined.

THIRTEENTH LECTURE.

THE MANUFACTURE OF COTTAGE CHEESE AND OF POTTED OR CLUB CHEESE.

Cottage or Dutch cheese is the product made by allowing milk to stand until it coagulates by ordinary souring, the curd being drained to allow the escape of much of the whey, after which it is salted, pressed into the form of balls, and is then ready for consumption.

1. *Material to use.*—Skim milk should be used. Whole milk loses too much of its fat in being made into cottage cheese.

2. *Preparation and use of starter.*—In making cottage cheese on a large scale considerable time can be saved by hastening the souring of the milk through the use of a starter prepared as described in Lecture 7, paragraphs 4 and 5. The character of the starter is of much importance. Impure starters may cause slimy fermentation, and from such curd the whey will not separate easily (reference No. 21, p. 34).

3. *Manufacture of cottage cheese without starter.*—The milk is kept at a temperature of 70° to 75° F. until well curdled, which will usually require twenty-four to forty-eight hours. The curdled mass is then broken by hand or cut by a curd knife and is heated gradually to 90° F. and is kept at this temperature until the whey appears clear. When the heat is so applied as to require thirty to forty minutes to reach 90° F., then the whey will usually separate clear in fifteen or twenty minutes. The whey is then removed and the curd is put into muslin bags or on racks and drained as long as whey runs. The curd is then

salted at the rate of 1 pound of salt for 100 pounds of curd, or to taste, shaped into pound or half-pound balls, and finally wrapped in oiled paper. For the finest quality of cheese, the curd before being made into balls should be mixed with thick cream, preferably ripened cream, at the rate of 1 ounce of cream for 1 pound of cheese (reference No. 21, p. 34).

4. *Manufacture of cottage cheese with use of starter.*—A good starter is added to milk at the rate of 2 or 3 pounds to 100 pounds of milk and thoroughly mixed through the mass of milk and then treated as described under the preceding paragraph 3 (reference No. 21, p. 35).

5. *Manufacture of cottage cheese with use of starter and rennet.*—The starter is added as described in paragraph 4 preceding, and about eight hours later rennet extract added at the rate of 1 ounce for 1,000 pounds of milk. The operation is completed as before described (reference No. 21, p. 35).

6. *Manufacture of cottage cheese by direct addition of hydrochloric acid.*—Have the milk at 70° to 80° F. Measure out pure hydrochloric acid, of specific gravity 1.20, at the rate of 10 ounces for 100 pounds of milk, dilute with ten times its bulk of water and add to milk gradually, stirring the milk constantly while the acid is being added. Continue the stirring until the curd separates completely, leaving a clear whey entirely free from milkiness. The whey is then run from the curd and the operation completed as before. In order to get the proper flavor, it will be necessary to mix with the curd some loppered milk or cream (reference No. 21, p. 35).

7. *Qualities of cottage cheese.*—(Reference No. 21, p. 36.) Flavor and texture are the most important qualities in cottage cheese. The flavor should be that of mildly soured milk or well-ripened cream. There should be an entire absence of all objectionable flavor, such as bitter taste, stable flavor, etc. If the cheese tastes too sour it is usually due to keeping too much whey in curd. The use of a starter is apt to insure the right kind of flavor. The texture of cottage cheese is largely dependent on the amount of moisture in the cheese. When the percentage of moisture is much below 70, the cheese is harsh, dry, and sawdust like. The right texture of cottage cheese is smooth and free from harshness.

8. *Yield of cottage cheese.*—From 100 pounds of milk one should obtain from 20 to 22 pounds of cheese. Variation in moisture makes much variation in yield (reference No. 21, p. 14).

9. *Composition of cottage cheese.*—Cottage cheese of the best texture contains 70 to 75 per cent of moisture. Curdling milk at too high a temperature and heating the curd too high or too long will make the cheese too dry. Cottage cheese contains about 3.5 to 4 per cent of milk sugar and 2 to 2.5 per cent of nitrogen, mostly in the form of casein lactate (reference No. 21, p. 14).

10. *Digestibility of cottage cheese.*—Cottage cheese is more readily digestible than fresh Cheddar cheese. Cottage cheese is ready for consumption as soon as made (reference No. 21, p. 33).

11. *The manufacture of potted or club cheese.*—This kind of cheese is on the market under various brand names, being put up in small jars. This is very easily prepared on a small scale. Take well-ripened Cheddar cheese of good quality, cut into small chunks and pass through a meat-grinding machine. To this ground cheese add 1 ounce of melted butter of good quality for each pound of cheese, and work it through the cheese mass until thoroughly incorporated. Pack this into small jars or jelly glasses, the inside surface of which has been smeared with melted butter. Cover the upper surface with a thin layer of melted butter and cover with paper. Keep in cool place until wanted for use.

EXPERIMENT AND PRACTICE WORK, THIRTEENTH LECTURE.

Time required.—The first day fifteen or twenty minutes will be sufficient to start the work. On the next day if the milk has fully curdled the operation can be completed in one or two hours.

Apparatus, etc., required.—Pails holding 25 pounds of milk and some means of controlling the temperature moderately are the chief utensils required besides a thermometer and some kind of a knife for cutting curd. Skim milk should be used, 20 pounds being enough for each student.

1. Make cottage cheese without starter, as described in paragraph 4.
2. Make cottage cheese with starter, preparing starter in the manner previously described. See paragraph 5.
3. Make cottage cheese with starter and rennet, according to paragraph 6.
4. In every case keep careful records of the work.

FOURTEENTH LECTURE.

METHODS OF PAYING FOR MILK FOR CHEESE MAKING.

1. *Weight-of-milk method.*—Until about 1894 the universal custom prevailed of paying for milk at cheese factories on the basis of the weight of milk furnished by each patron. This method is still common. It is based upon the false belief that all kinds of milk are of the same value for cheese making. The data presented in Lecture 2 show that this claim is entirely wrong. We know that milk varies greatly in composition, and the composition determines the cheese-making value.

2. *Difficulty of absolute fairness.*—In paying for milk at factories absolute fairness can be realized in every individual case only by knowing two points: (1) The amount of cheese that is made from each

milk and (2) the quality of such cheese. The exact amount of cheese produced can be ascertained only by a careful, direct determination of both fat and casein, the two solid constituents of milk that make cheese; but this is not practicable. The quality of cheese is quite dependent upon the per cent of fat in milk, assuming the milk to be clean in every way.

3. *Fat as a basis for fixing value of cheese milk.*—Fat in milk can be used as a fair basis in determining the value of milk for cheese making for two reasons: (1) The amount of cheese made from different milks is nearly in proportion to the amount of fat present in milk (see Lecture 2, paragraph 6). (2) Cheese made from milk rich in fat is higher in quality than cheese made from milk poorer in fat.

4. *Paying for milk on basis of weight of milk.*—When milk is paid for by weight alone, each patron receives money in proportion to the amount of milk taken; but each patron receives for 100 pounds of milk the same amount of money every other patron receives, without reference to the amount of cheese each patron's milk will produce.

5. *Paying for milk on basis of amount of fat in milk.*—To illustrate this method, we assume that two patrons furnish milk, one of which (A) contains 3 per cent of fat and the other (B) 4 per cent. The amount of cheese made from 100 pounds of milk A is 8.55 and that from milk B 10.65, or a total of 19.2 pounds, which sells at 10 cents a pound, or 192 cents. On the weight-of-milk basis each receives one-half, or 96 cents. On the basis of the fat in the milk one (A) receives three-sevenths, 82.3 cents, and the other (B) four-sevenths of the money, 109.7 cents.

6. *Comparison of two methods.*—The following table shows the result of paying for milk according to weight and according to fat content:

Paying for milk by weight and by fat content.

Name of patron.	Fat in 100 pounds of milk.	Cheese made from 100 pounds of milk.	Amount of money received when divided on fat basis.	Amount of money received when divided according to weight of milk.
	Pounds.	*Pounds.*	*Cents.*	*Cents.*
A	3	8.55	82.3	96
B	4	10.65	109.7	96

Notice the following facts: (1) By weight-of-milk method A receives same amount of money for 8.55 pounds of cheese that B does for 10.65 pounds. (2) A receives over 11 cents a pound for cheese, while B receives only 9 cents. (3) A receives 32 cents a pound for milk fat, while B receives only 24 cents. (4) A receives on 100 pounds of milk 13.7 cents, which really belongs to B. (5) One method makes no difference, while there really exists a difference of 27.4 cents in favor of B.

7. *Method of allowing for both casein and fat.*—In some factories, especially in Canada, the casein is taken into account in making dividends. This is done by adding 2 to the per cent of fat, on the assumption that all milks contain only 2 per cent of casein and that the figures thus obtained approximate more closely the cheese yields of different milks. This method is objectionable for the following reasons: (1) The poorest factory milk contains about 2 per cent of casein, while richer milks contain more (see Lecture 2, paragraph 5). By this method the richer milk does not get its full credit of casein and cheese yield. (2) This method is in favor of the poorer milk. (3) It makes no recognition of the fact that rich milk produces better quality of cheese than poor milk.

8. *Summary of reasons for using the milk fat basis in paying for milk at cheese factories*—

First. Because the amount of fat in milk offers the most accurate, practicable, and just basis we have for determining the cheese-producing value of milk.

Second. Because this method recognizes the fundamental truth that different milks possess different values for cheese making.

Third. Because this method, being based on truth, is just to all and is therefore in the highest sense businesslike.

Fourth. Because the adoption of this method results in an improvement in the quality of milk produced. It makes it pay to produce better milk.

Fifth. Because all temptation to adulterate milk by watering or skimming is removed, since a man receives pay for the number of pounds of fat he furnishes.

Sixth. Because improvement in the character of dairy animals will follow, and in consequence the yield and composition of milk, which means economy of production and increased profit.

9. *Method of making cheese-factory dividends on basis of milk fat.*—Several methods may be employed to determine the amount of each patron's dividend. Calculators are published, which save most of the details of figuring. We will present here the simplest methods, showing the necessary details. We want to calculate the dividends for one dividend period, whether a week or month. We must know four items: (1) The amount of milk delivered by each patron during the dividend period; (2) the per cent of fat in the milk for the same time; (3) total or gross amount of money received for the cheese produced during the same period, and (4) the expenses to be deducted from gross receipts, such as cost of manufacture, selling, carting, etc. Having these data, we need only to apply the following rule, which is stated, for convenience, in three steps:

Rule, step 1. To find the amount of milk fat furnished by each patron: Multiply together the per cent of fat in the milk and the amount of milk delivered by each patron, expressed in hundreds of pounds and decimals of a hundred. This gives the total amount of fat in the milk delivered by each patron during the dividend period. The following table illustrates this calculation:

Illustration of method of calculating milk fat delivered by patrons.

Name of patron.	Pounds of milk delivered during dividend period by each patron.	Pounds of milk expressed in decimals of 100 pounds.	Per cent of fat in milk during period.	Pounds of fat in milk delivered by each patron.
A	350	3.50	4.0	14.00
B	650	6.50	3.6	23.40
C	835	8.35	5.2	43.42
D	965	9.65	4.4	42.46
E	1,200	12.00	4.2	50.40
Total				173.68

Rule, step 2. To find the net value of 1 pound of milk fat: Divide the total net receipts by the total number of pounds of milk fat delivered by all the patrons during the dividend period. Example: From the amount of milk delivered by patrons, as previously given, there have been made, say, 452 pounds, which realizes 9 cents a pound after deducting all expenses. This will leave $40.68 to distribute among the patrons. We now divide $40.68 by 173.68, the total pounds of fat delivered by all patrons during the dividend period, and we have 23.42 cents as the net amount of money received from cheese for each pound of milk fat delivered.

Rule, step 3. To find the amount of dividend due each patron: Multiply together the number representing the pounds of milk fat furnished by each patron and the net price received for each pound of milk fat. In this case the net price received for each pound of milk fat is 23.42 cents, and we multiply by this the number of pounds of fat delivered by each patron. Example:

Name of patron.	Pounds of fat in milk delivered.	Net price received for each pound of fat.	Amount of money received by each patron.
A	14.00	$0.2342	$3.28
B	23.40	.2342	5.48
C	43.42	.2342	10.17
D	42.46	.2342	9.95
E	50.40	.2342	11.80

10. *Examples for practice*—

(1) A has 20 cows, which give each 30 pounds of milk a day, testing 4½ per cent of fat. B has 30 cows, each giving 25 pounds of milk a day, testing 3½ per cent of fat. (a) Which herd produces more milk fat per week, and how much? (b) If there is made daily from the milk of these

two herds 140 pounds of cheese, selling at 10 cents a pound net, what will be the dividend of each for thirty days on the basis of the weight of milk delivered by each? (c) What will be the monthly dividend of each on the milk-fat basis? (d) Does A gain or lose by milk-fat basis, and how much a month? (e) Does B gain or lose by weight of milk basis, and how much a month? (f) Calculate A's and B's daily gain or loss per cow for season of 180 days by each method of making dividends.

(2) A dairyman's herd produced during the factory season 18,000 pounds of milk, which contained 684 pounds of milk fat. (a) What was the average per cent of fat in the milk during the season? (b) How much ripened cheese did the milk produce, allowing 2.6 pounds of cheese for 1 pound of milk fat? (c) How much milk was required to make 1 pound of cheese? (d) How much cheese was made from 100 pounds of milk?

(3) Herd A with 10 cows produces during the factory season 36,000 pounds of milk, containing 3.6 per cent of fat. Herd B with 8 cows produces 30,000 pounds of milk, containing 4.5 per cent of fat. (a) Which herd produces more milk fat, and how much? (b) What will be the receipts of each herd on the milk-fat basis, assuming that each pound of milk fat nets 20 cents? (c) What would be the difference in the dividends of each, if payment were made on basis of weight of milk? (d) Assuming that the cost of keeping each cow is the same, which is the more profitable herd?

APPENDIX.

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Handbook for Farmers and Dairymen. By F. W. Woll, Ph. D. Published by John Wiley & Sons, New York City.

Reports of New York State and Wisconsin Agricultural Experiment Stations from 1892 to date. These are largely out of print, but are available for reference in libraries of agricultural colleges and experiment stations.

Dairy Chemistry. By Henry Droop Richmond. Published by J. B. Lippincott & Co., Philadelphia, Pa., 1900. This work is recommended where one has some knowledge of chemistry and desires to go deeply into the subject of dairy chemistry.

LIST OF APPARATUS AND MATERIALS NEEDED.

[Prices are retail catalogue prices, subject to some discount.]

1 cheese vat, self-heating, 100 gallons, divided into four equal compartments	$50.00
1 standing cheese press, 4 screws 1¾ by 20 inches high	35.00
Galvanized steel cheese hoops for standing press—	
4 Young America, 7 by 9 inches, at $2	8.00
4 Young America, 12 by 8 inches, at $2.15	8.60
2 Young America, 14½ by 10 inches, at $2.80	5.60
6 fibrous press rings for 12 by 8 inch hoops, at $0.35	2.10
6 fibrous press rings for 14½ by 10 inch hoops, at $0.35	2.10
6 fibrous press rings for 7 by 9 inch hoops, at $0.25	1.50
1 bandage for Young America hoop	.50
1 bandage for 12 by 8 inches	.75
1 bandage for 14½ by 10 inches	.75
100 cheese bandages, 7 by 9 inches	1.00
100 cheese bandages, 12 by 8 inches	1.35
100 cheese bandages, 14½ by 10 inches	1.80
1 pair curd knives, 8 by 22 inches perpendicular and 6 by 22 inches horizontal	4.20
1 special 240-pound combination scale	2.50
1 flat side curd pail	1.00
1 curd scoop	.65
1 gallon dipper	.65
1 whey siphon with gate and valve	2.00
1 whey strainer	.80
3 new standard large bulb-floating, dairy-guaranteed correct thermometers, at $0.50	1.50
1 vat scrub brush	.25
1 cheese trier, 6 by ¾ inches	.90
4 ounces cheese color	.25
1 gallon rennet extract	1.60
Or 50 rennet tablets	2.20
Babcock tester traveling outfit, 4-bottle size (or larger)	10.00
12 test bottles, for whole milk	4.20
12 test bottles, double bore skim milk and whey	5.00
6 test bottles, for cream or cheese	1.00
1 gallon sulphuric acid of proper strength	.70
1 Farrington's alkaline acid tests for milk, whey, etc	2.75 and 4.75
1 Mann's acid test	4.75

1 testing scale for weighing solids with metric weights	$8.00
1 milk sampler	1.00
1 Marschall rennet test	2.50
1 Monrad rennet test	1.00
1 graduate, 8-ounce	.30
1 hygrometer for determining moisture	1.50
1 10-inch hair sieve	.60
3 1-cubic-centimeter pipettes, at 10 cents	.30
3 10-cubic-centimeter pipettes, divided into tenths, at 20 cents	.60
1 milk-bottle tester (brass plunger)	.75
2 Quevenne lactometers	1.00
1 New York State Board of Health lacto-thermometer	1.50
1 test jar for lactometer, 11 by 2	.30
6 Petri dishes, at 30 cents	1.80
24 test tubes, 5 inches by 5/8 inch, at 30 cents per dozen	.60

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Bulletin No. 120. Proceedings of the Seventh Annual Meeting of the American Association of Farmers' Institute Workers, held at Washington, D. C., June 24-26, 1902. Edited by A. C. True and D. J. Crosby for the Office of Experiment Stations, and G. C. Creelman for the Association. Pp. 119.

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 167.

A. C. TRUE, Director.

IRRIGATION

IN THE

NORTH ATLANTIC STATES.

BY

AUG. J. BOWIE, JR.,

AGENT AND EXPERT.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

LIST OF PUBLICATIONS OF THE OFFICE OF EXPERIMENT STATIONS ON IRRIGATION AND DRAINAGE.

NOTE.—Publications marked with an asterisk (*) are not available for distribution.

- *Bul. 36. Notes on Irrigation in Connecticut and New Jersey. By C. S. Phelps and E. B. Voorhees. Pp. 64.
- *Bul. 58. Water Rights on the Missouri River and its Tributaries. By Elwood Mead. Pp. 80.
- Bul. 60. Abstract of Laws for Acquiring Titles to Water from the Missouri River and its Tributaries, with the Legal Forms in Use. Compiled by Elwood Mead. Pp. 77.
- Bul. 70. Water-Right Problems of Bear River. By Clarence T. Johnston and Joseph A. Breckons. Pp. 40.
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- Bul. 131. Plans of structures in use on irrigation canals in the United States, from drawings exhibited by the Office of Experiment Stations at Paris, in 1900, and at Buffalo, in 1901, prepared under the direction of Elwood Mead, chief. Pp. 51.
- Bul. 133. Report of Irrigation Investigations for 1902, under the direction of Elwood Mead, chief. Pp. 266.
- Bul. 134. Storage of Water on Cache la Poudre and Big Thompson Rivers. By C. E. Tait. Pp. 100.

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A. C. TRUE, Director.

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IN THE

NORTH ATLANTIC STATES.

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AGENT AND EXPERT.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., April 16, 1906.

SIR: I have the honor to transmit herewith a report on Irrigation in the North Atlantic States, by Aug. J. Bowie, jr., of the Irrigation and Drainage Investigations of this Office. This report shows that for market gardens and for meadows irrigation in humid sections has proven profitable, but it has not yet been practiced in the raising of general farm crops. The cost of securing water supplies in the East far exceeds that in the arid regions, although water is much more plentiful. This suggests that it may be possible to so reduce the cost of water as to render irrigation profitable for many crops which will not repay the expense now incurred. The descriptions of irrigation practice contained in this report should be suggestive to many who are now raising truck without the aid of irrigation, and it is therefore recommended that the report be published as a bulletin of this Office.

Respectfully,

A. C. TRUE,
Director.

HON. JAMES WILSON,
Secretary of Agriculture.

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3. Adjustable nozzle 39

4. Adjustable hydrant with hose and nozzle 40

5. Simple nozzle 46

6. Nozzle 47

7. Multiple sprinkler 48

IRRIGATION IN THE NORTH ATLANTIC STATES.[a]

The data for this report were collected during July and August, 1905, and include a study of irrigation as practiced in Maryland, Delaware, Pennsylvania, New Jersey, New York, Rhode Island, and Massachusetts. The territory investigated lies in the humid district of the United States, where the annual rainfall is between 40 and 50 inches. Irrigation is not always necessary for the growth of crops and has been confined to truck farms and meadow land.

FIELD FOR IRRIGATION IN HUMID CLIMATES.

According to the popular conception, the field for irrigation is the arid or semiarid region in the West, and does not extend to the humid East, where the supply of moisture is considered sufficient for the growth of crops. The distribution of rainfall, however, is so uncertain that crops throughout the East often suffer from droughts. Without irrigation certain crops, such as strawberries, celery, and cauliflower, may be entirely lost. It is not uncommon to see farmers making frantic efforts to save their crops from destruction by hauling water and sprinkling from barrels and watering pots. The water applied in this manner is too small in quantity to be of any service and is very costly. Economical and successful methods of irrigation adapted to humid conditions are, however, quite extensively used and are described in this report.

The advantages to be gained from irrigation are limited to certain crops. Such field crops as timothy, clover, wheat, rye, oats, and corn are not particularly affected by droughts of short duration. The value of such crops in eastern Pennsylvania will usually lie between $15 and $30 per acre, and irrigation in such instances would hardly pay under present conditions. The case of truck crops is entirely different. The value of a single crop will often be $200 to $1,500 per acre, and usually two to three crops are grown on the same land in a year. Crops of this nature are much more sensitive to drought than field crops. Particularly is this true in the case of berries during the time when the fruit is maturing. Failure to provide sufficient moisture during this period may result in very great damage to the crop.

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[a] Previous studies of irrigation in the East have been reported in U. S. Dept. Agr., Office of Experiment Stations Buls. 36, 87, 119, 133, 148, and Farmers' Bul. 46.

The irrigation of truck not only greatly increases the yield, but it matures the crops earlier, when they will bring higher prices, and may allow the growth of one more crop during the year. It is particularly during the years of greatest drought that the truck farmer who irrigates reaps his harvest, when prices are highest and his neighbors' crops poorest in quantity and quality. The distribution of rain is by no means uniform, even in adjoining counties, and certain localities, owing to the topography of the land, fail to receive many of the showers which fall on the surrounding country.

It is commonly said that truck irrigation will pay only when the market is close at hand, but much of the data presented show good returns from the irrigation of truck land rather unfavorably situated. In addition to truck gardens there are in many localities low meadow lands which may be cheaply irrigated, and these two types of irrigation practice constitute the present field for irrigation in the humid East.

TOPOGRAPHY.

The land of the humid belt in the eastern and northeastern part of the United States is generally of a rolling hilly nature, totally unlike the broad level plains and valleys of the West. The difficulties of preparing for irrigation large sections of land are correspondingly greater. Comparatively few large farms, however, are found through the East, the land being cut up into smaller holdings. Of the territory investigated, eastern Maryland, Delaware, southern and eastern New Jersey, and Long Island are fairly level, while in eastern Pennsylvania and northwestern New Jersey the land is nearly all hilly.

RAINFALL.

The following table is taken from the Weather Bureau reports to show for the section investigated the large variations in the annual and seasonal rainfall for the last ten years. The "normal" rainfall is simply the average since records have been kept.

Annual and seasonal rainfall in eastern cities from 1895 to 1904.

Year.	Boston.		New York.		Harrisburg.		Philadelphia.	
	Annual.	April to September.	Annual.	April to September.	Annual.	April to September.	Annual.	April to September.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1895	40	16	36	17	26	13	31	15
1896	38	18	38	20	35	18	32	14
1897	41	22	44	26	34	18	42	24
1898	50	25	45	19	45	26	49	24
1899	36	15	42	20	34	20	40	18
1900	44	19	42	19	29	15	41	22
1901	49	26	47	29	30	17	46	28
1902	34	13	47	21	40	18	50	22
1903	....	21	....	22	....	19	....	21
1904	40	....	42	....	32	....	40	....
Normal	45	22	45	22	44	24	40	21

It is seen that in dry seasons there is about half as much rain as in wet, and that about one year in three has less than 75 per cent of the normal rainfall. The following table shows the monthly rainfall during the crop-growing months for the same period and is inserted to show that even in seasons of normal or excessive rainfall, as in 1901 or 1903, there may be a dry month which will greatly retard growth.

Monthly rainfall in Philadelphia from 1895 to 1904.

Year.	April.	May.	June.	July.	August.	September.	Total.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1895	6.1	1.7	3.2	3.2	0.6	0.6	15.4
1896	1.2	2.3	4.1	3.3	.5	2.8	14.2
1897	3.0	4.3	4.5	7.7	3.5	1.1	24.1
1898	2.9	4.8	1.8	3.6	9.1	1.8	24.0
1899	1.0	2.3	1.1	4.7	5.2	3.7	18.0
1900	1.9	4.1	2.8	2.8	4.0	6.3	21.9
1901	4.8	4.1	1.2	4.9	9.4	3.7	28.1
1902	3.3	2.0	6.1	3.5	2.3	5.0	22.2
1903	3.0	.9	5.5	3.8	5.6	2.3	21.1
1904	....	....	2.9	3.8	4.4	7.2	....
1905	3.6	....	1.8	....	....	....	....
Normal	3.0	3.2	3.1	4.2	4.3	3.3	21.1

WATER SUPPLY.

Most of the irrigated meadow land in Pennsylvania lies near the beds of small creeks fed by springs. The flow of the springs varies considerably during the year, many of them drying up, so that part of the year the water supply is insufficient for irrigation, or ceases altogether. Small dams constructed of timber back filled with earth are built to raise the water sufficiently high to cover the land, but not for storage. They are usually small affairs, cheaply constructed, costing from $5 to $20. When washed out they are often not replaced for a year or two, the land meanwhile going unirrigated.

The use of wells as a source of irrigation is quite limited, and throughout the East the absence of windmills is particularly noticeable. The cost of well boring is considerably higher than in the South and West.

Many farmers near the large cities use city water for irrigation, since, if the farm is small and the use of water is limited, it is thought to be cheaper than pumping. The usual cost of such water is $1 to $1.50 per 1,000 cubic feet, or $44 to $65 per acre-foot—a price which would certainly seem prohibitive to western irrigators, some of whom pay less than 1 per cent of these costs, and even where pumping is practiced, as in Santa Clara Valley, California, the average cost of raising water 65 feet is only $4.40 per acre-foot, or 10 per cent of the above price. The success of irrigation under the conditions found in the East is due not to cheap water supply, but to the high value of crops grown and the careful distribution of the small quantity of water used.

MEADOW IRRIGATION.

The table given below gives the location and area of 125 irrigated meadows in four counties of Pennsylvania, with such data as could be obtained regarding their yield and the yield of similar land without irrigation:

Irrigated meadows in Pennsylvania.

Name.	County.	Area.	Yield per acre.	
			Irrigated.	Nonirrigated.
		Acres.	*Tons.*	*Tons.*
B. Caskey	Lancaster	7	2	1
Elias Breckbill	do	5	2	
J. Keener	do	2		
J. Bachman	do	9	2.4	
David Myers	do	1		
J. Mellinger	do			
Newt. Herr	do	7	2	1
John Beiler	do	4	2	1.5
Sam Martin	do	3	.8	.6
Jacob Zimmerman	do	5		
Joe Weaver	do	4		
David Martin	do	5		
David Rut	do	3		
A. H. Weaver	do	2		
C. H. Zimmerman	do	8	2.8	1.4
Frank Weaver	do	3		
Joe Weaver	do	3		
I. G. Martin	do	2	2.2	1.1
Amos Hostetter	do	10	2.9	
J. W. Morrison	do	2	3.2	1.6
Jacob Thomas	do	5		
H. Yoder	Berks	35	2.9	.6
J. H. Ruth	do	16	1.5	1.5
State Insane Asylum	do	65	3	
Reading Poorhouse	do	30	1.5	.7
F. J. Trexler	do	3	2.4	1.2
C. B. Adams	do	3	1.5	1
John Sell	do	2	2.3	
Peter Swoyer	do	3	2.7	
Abe Schlegel, jr	do	1		
Do	do	5		
Aaron Houck	do	4	2.3	1.1
Eph. Leh	do	4		
William Edinger	do	3		
Jim Andy	do	2	2.5	1.5
Oscar Houseman	do	1		
J. D. Kuser	do	6	Double.	
Emma Hassler	do		1.6	
W. Keim	do	5	2	.5
Sarah Butz	do	8	2.9	.9
John Bechtel	do		2.2	1.5
William Wolfgang	do	9	2	
J. K. Mest	do	4	1.5	.7
Jacob Moyer	do	3	1.5	.8
Alvin Weller	do	3	2.3	
Aaron Weller	do	3		
Mathias Miller	do	2	3.1	1.3
David Yoder	do	3	5	2.4
Joe Moyer	do	2		
Sam Wise	do	10	1.5	.8
Ephraim Weller	do	3	2.3	1.1
R. S. Gilbert	do	8	1.5	1.1
William Landis	do	5	2.4	
E. B. Yingting	do	3	2.5	1.2
Calvin Shane	do	4	2	
H. Wolfgang	do	5	2.1	1
G. W. Amey	do	5	2.6	
Jacob Knecht	do	5	2.5	
John Hufford	do	20		
Jacob Kulp	do	8	1.5	
Henry Apple	do	8	1.9	.9
M. T. Hess	do			
Jake Moyer	do	8	2.3	
John Fluck	do	5	3	
John H. Rueh	do	5	1.8	.9
Noah Geissinger	do	2	2.5	1.2
Newt. Moyer	do	13	2.9	1.4

Irrigated meadows in Pennsylvania—Continued.

Name.	County.	Area.	Yield per acre.	
			Irrigated.	Nonirrigated.
		Acres.	*Tons.*	*Tons.*
John Moyer	Berks	8	2.1	1
John Ernst	do	12		
P. H. Carl	Lehigh	2	1.5	1
C. H. Kline	do	4	1.8	.9
F. Gehman	do	3	2.7	
John Rothenberger	do	2	2.8	
D. M. Shantz	do	2	3	1.4
J. Rhoad	do	8	3	
J. C. Ackerman	do	8	3	1.4
H. B. Schelly	do	1	2	.9
Schuler Brothers	do	7	2.1	1
L. Ritter	do	8	1.6	
H. D. Gross	do	5	2.2	1.1
Jacob Young	Northampton	8	1.8	1.4
J. M. Weiss	do	3	1	
James P. Abel	do	6		
Sol S. Stevens	do	29	1.7	
F. O. Border	do	1		
T. L. Laubach	do	10	2	
W. V. Schweitzer	do	15	3	
Tom Kunsman	do	2		
A. H. Skinner	do	2		
T. F. Kunsman	do	6	1.7	
H. Illick	do	10		
J. J. Detweiler	do	4		
J. Davis	do	13		
T. Mitman	do	10		
William Ruch	do	8		
B. F. Fulmer	do	3		
A. Cressman	do	8		
John Rodenbach	do	7		
Preston Roth	do	5		
J. P. Kline	do	4		
David Unangst	do	5		
Howard Yelles	do	8		
Frank Rigg	do	6		
William Cauley	do	10		
A. T. Kunsman	do	5		
A. T. Burkstrasser	do	5		
Theo. Floubach	do	11		
John Boyer	do			
William Herrmann	do	12		
Mrs. Lurch	do	5		
William M. Applegate	do	7		
Dr. O. B. Schaeffer	do	6		
J. Fanceboner	do	6	2	1.2
Will Fanceboner	do	6	1	
Ben Buzzard	do	7	3	1.4
A. W. Sandt	do	2	2.3	
Julius Karabinus	do	7		
Alfred Remaley	do	15		
Charles Holland	do	6	2	
J. F. Engler	do	1	2	.8
J. Rush	do	3	2.2	
Franklin Hester	do	5	4	
R. D. Good	do	12	3	
— Strohe	do	4	4	
O. H. Emery	do	10	3	
Hiram and G. A. Yetter	do	10		

The entire area included in the table is over 800 acres, showing that meadow irrigation is a well-established practice in this region. In the 41 cases where an estimate of the yield from similar land not irrigated is given, 270 acres are reported as producing 570 tons of hay when irrigated and 270 tons when not irrigated, showing that irrigation is thought fully to double the yield.

More detailed data regarding a few typical meadows are added below to give a general idea of the methods employed.

LANCASTER COUNTY.

B. Caskey irrigates 7 acres, which yield 2 tons of hay to the acre in two cuttings. Water is run continuously over the same piece for about three weeks.

David Martin and four others irrigate 19 acres from Blue Ball Run. The water is diverted into a partnership ditch 3 feet wide and 2 feet deep, nearly a mile in length, which was built seventy years ago. Water is usually applied twice before each cutting and once immediately afterwards and runs continuously for three or four days for each irrigation. It is distributed over the land by means of small cuts in the side of the ditch, 12 to 15 feet apart. Where the ditch runs on a steep grade, boards or stakes are inserted to check the water. Repairs are said to cost $5 a year. Three acres yielded 10 tons of hay or three times the yield of unirrigated land.

A. H. Weaver irrigates 2 acres from a spring. Water is run continuously for five days on the same piece of land, being applied in eight irrigations a month apart. After each irrigation the land is allowed to dry for two days, when stock is turned in to graze for the next three weeks. Irrigated land will pasture 3 head of stock per acre, whereas nonirrigated land will support only 1 head. The owner estimates the value of irrigated pasture per head per month at $2, and of nonirrigated pasture where the quality of grass is not so good at $1.50. Hence, allowing for the week during which irrigated land is not available for pasturage, the annual value of irrigated meadow land in the seven months from the middle of April to the middle of November is $31.50 per acre, while the annual value of nonirrigated meadow land per acre is $10.50. The annual cost of applying water to the land is but $4; hence the net annual return is approximately $17 per acre for irrigated land.

Amos Hostetter irrigates 10 acres, which is cut twice and pastured. The yield per acre is about 3 tons. Irrigation is begun about the 1st of June, and the first crop cut about ten days later. Water is run continuously from one to two days on the same piece of land and is usually applied every week. The crop of hay on nonirrigated land is hardly worth cutting. It takes one man two and a half days to clean the ditch each year.

J. W. Morrison irrigates 1½ acres, which yield 5 tons a year in two cuttings. Irrigation fully doubles the yield. Water is applied every ten days and runs continuously on the same piece of land for five days. The cost of the irrigation per year is about $5.

BERKS COUNTY.

At the Reading poorhouse there are irrigated 30 acres, yielding 1½ tons to the acre in one cutting in June, after which the land is pastured. Water is run continuously from the middle of March to the middle of

June, and about the end of June the first crop is cut. If the weather remains dry the land is irrigated for pasture. Irrigation doubles the yield.

At the State Insane Asylum there are irrigated 65 acres of grass with sewage water, which is pumped into a reservoir on a hill and distributed through pipes and 2½-inch canvas hose, from which the water discharges freely over the land. The yield of hay is 2½ tons per acre. This irrigation plant is described at length on page 16.

Mrs. Sarah Butz formerly irrigated 8 acres yielding about 3 tons per acre in two cuttings. An embankment for a trolley-line has recently been erected through the farm, and as no provision has been made for conveying the water through the embankment the farm was not irrigated the past year, with the result that the yield was reduced to less than a ton per acre.

G. W. Amey irrigates from a spring 5 acres, which yield two and sometimes three crops, or a total of 13 tons per year. The owner believes that irrigation doubles the crop. The same piece is irrigated continuously for a month.

In the vicinity of Richlandtown are a few farms where meadow land is irrigated by surface drainage from the roads. No reliable figures, however, could be obtained of the value of such irrigation.

Jacob Knecht irrigates 5 acres, which yield 1½ tons per acre. The crop from nonirrigated land is hardly worth cutting. The land in the past has been irrigated once a week, the water running continuously for three days on the same piece. The owner thinks the water should be changed every day and that the farm has suffered from overirrigation. A considerable growth of sour grass, which is mainly due to overirrigation, may be seen in many other places throughout the country.

LEHIGH COUNTY.

C. H. Kline irrigates 4 acres, yielding nearly 2 tons per acre in two cuttings. Nonirrigated land has only half this yield. Water is applied continuously for five days, every three weeks, the first crop receiving six irrigations and the second crop four.

J. C. Ackerman irrigates 8 acres, yielding 2 tons per acre for the first crop and 1 ton per acre for the second crop, after which the land is pastured. The land is irrigated once a week, the water running continuously for a day on the same piece. The first crop receives twelve irrigations, starting in April, and the second crop eight. The time required to change the water is not over a quarter of an hour a day. Twenty-five head of cattle are wintered on the hay from 8 acres.

NORTHAMPTON COUNTY.

W. V. Schweitzer irrigates 15 acres, which have been irrigated 45 years. The first crop is cut early in June and yields 1⅓ tons per acre; the second crop yields 1 ton, the third crop ⅔ of a ton. After the third crop is cut the land is irrigated when necessary and then pastured. The water supply is obtained from the stream which supplies the mill and is used when the mill is not in operation. One tract of meadow land was fertilized by the addition of 300 pounds of fertilizer and ashes to the acre, increasing the yield materially. On the average irrigation increases the yield of the land threefold. Every third year the meadow is cut only twice in order to allow the grass to reseed itself, the first cutting being made about June 24. In the early spring when water is plentiful the land is thoroughly fertilized by opening a large drainpipe in the headrace and washing over the land the mud and sediment gathered there.

A. H. Skinner has two 4-acre pastures; while one is being irrigated the other serves as pasture. One irrigation lasts for six weeks, and one irrigated pasture will support 8 head of cattle, whereas nonirrigated land will support only half as many.

The data given are enough to show that the crude methods used for meadow irrigation are successful, and on the small scale at present practiced are cheap to install and operate. They suggest but do not demonstrate what could be done with a well-built system on a large tract. Many of the meadows have suffered from overirrigation, shown by a growth of sour grass in spots. This usually indicates uneven watering rather than an excess of water on the whole tract, and in many cases could be remedied by running small furrows down through the field, 4 or 5 feet apart, with a single shovel or a special cultivator attachment cutting through the turf. They should have grade enough to carry the water easily and may often be run from the head ditch in the direction of the greatest slope. This method is very common in Utah and Nevada for all field crops, where the inconvenience in mowing across the furrows and the loss of grass or alfalfa in the furrows is found to be very small.

IRRIGATION OF TRUCK FARMS.

The following list of truck farms, most of which are described later in detail, shows the location and area of each farm. These farms are referred to in the subsequent discussion by their numbers, as given in the list below:

Irrigated truck farms.

No.	Name.	State.	County.	Area.
				Acres.
1	Louis Chassagne	Maryland	Baltimore	6
2	N. H. Mack	Pennsylvania	Lancaster	4
3	State Insane Asylum	do	Berks	105
4	P. B. Dilks	do	Philadelphia	3
5	M. V. Dilks	do	do	1
6	Alfred Paul	do	Montgomery	1
7	U. J. Wieand	do	Lehigh	4
8	John F. Weaver	do	Northampton	3.5
9	Ed C. Schaefer	do	do	4
10	Julius Karabinus	do	do	1
11	J. F. Engler	do	do	1
12	Harry Broadhead	do	Monroe	0.3
13	R. F. Schwarz	do	do	5
14	M. Garrahan	do	Luzerne	9
15	Mrs. R. C. Shannon	do	Northumberland	2
16	W. J. Suter	do	do	2
17	C. McWilliams	do	do	1.5
18	F. W. Kilbourne	New Jersey	Middlesex	2
19	W. P. Stokes	do	Burlington	......
20	Henry A. Dreer	do	do	5
21	T. R. Hunt	do	Hunterdon	6
22	David Astle	do	Cumberland	1.6
23	Cuno Becker	do	do	......
24	State Asylum for Feeble-Minded Children	do	do	16
25	William Ash	do	do	3
26	George Mitchell	do	do	10
27	J. H. Shute	do	Gloucester	1
28	L. M. Parkhurst	do	Atlantic	3
29	Hermann Graumann	do	do	10
30	John I. Sickles	do	Monmouth	6
31	Julius Roehrs	do	Bergen	......
32	William Young	do	Essex	12
33	F. J. Forthuber	do	do	15
34	Henry Schumacher	do	Morris	10
35	John Wilhelm	do	Hudson	......
36	Arthur Robinson	do	do	2
37	W. Gurnheit	do	do	15
38	F. Schumacher	New York	Queens	15
39	Phillip Bach	do	do	7
40	Witte Bros	do	do	18
41	B. H. Mohlenhoff	do	do	3
42	August Plenge	do	do	4
43	John Schumacher	do	do	4
44	Bender Bros	do	do	17
45	Frank Coolidge	Massachusetts	Middlesex	100
46	W. W. Rawson	do	do	40
47	Weyman Bros	do	do	40
48	James Purcell	do	do	10
49	W. H. Allen	do	do	95
50	Hittinger Fruit Co	do	Suffolk	......
51	C. H. Slade	do	do	10
52	A. H. Long	do	do	1
53	H. W. Locke	do	Middlesex	10
54	Lovell Bros	do	do	2
55	Pierce Bros	do	do	6
56	J. W. Russell	do	do	26
57	D. N. Potter	Rhode Island	Providence	22
58	C. W. Patt	do	do	32

DETAILED DESCRIPTIONS OF IRRIGATION PLANTS.

MARYLAND.

No. 1. Louis Chassagne, of Baltimore County, irrigates 6 acres of garden truck with water from the city main, costing 6 cents per thousand gallons, or $19.50 per acre-foot. In 1904, 4 acres were irrigated, and in 1905, owing to the wetness of the season, only one-half acre. The soil is a sandy loam 12 inches thick, with a sandy subsoil. The furrow system and sprinkling are both used. In very dry weather the land is irrigated every two weeks and is sprinkled twice a week, receiving at most not over three irrigations per crop. The furrows are 18 to 24 inches apart and 200 feet long. The water supply is sufficient to water 1 acre to a depth of 5½ inches in forty-eight hours. This is the maximum quantity of water applied at one irrigation, and frequently half this quantity is sufficient. The depth applied by sprinkling is very small compared with this. The ground is piped with 1½-inch second-hand piping, which cost $200.

The crops irrigated are celery, lettuce, and cauliflower, the celery being only sprinkled. The cost of labor is $4.50 per week and board. The owner estimates that in some years irrigation increases the returns fully $1,000, and that as a rule it doubles the yield. The value of the crops irrigated, per acre, are: Celery, $350 to $500; lettuce, $150; cauliflower, $200; celeriac, $300 to $500. During a drought irrigated cauliflower is cut two weeks earlier than unirrigated, and it brings twice as high a price. In 1904 celeriac not irrigated was hardly marketable. Irrigated beets were ten days ahead of those not irrigated. In the drought of 1901 the crop from 1 acre of irrigated lettuce sold for $400, at 75 cents to $1.25 per bushel. Unirrigated lettuce was a total failure. The cost of water was $40 in 1904 and $6 in 1905.

PENNSYLVANIA.

No. 2. At the Welsh Industrial Mission 4 acres in strawberries are irrigated from a spring by the furrow system. The land usually receives two irrigations a week apart. The water requires three to four hours to run through the furrows, which are 260 to 300 feet long and 3½ feet apart, the plants being set 18 inches apart. The yield of irrigated berries is 4,800 boxes per acre, the average price being from 5 to 10 cents per box. During a dry season a few years ago berries brought 7 to 15 cents a box, $336 to $720 an acre, at a time when the entire crop in the valley below was a failure. The superintendent, Mr. Mack, does not attribute the results wholly to irrigation, but estimates that it produces an increase of 25 bushels, or 800 boxes, per acre, since the soil and climate at the mission are more favorable than in the valley. In 1904 but 2 acres were irrigated.

No. 3. The State Insane Asylum at Wernersville irrigates 105 acres with sewage, the disposal of which is the primary object of the plant. Sixty-five acres are in grass, yielding 2½ tons per acre, and 40 acres in potatoes, yielding 150 bushels per acre. The sewage is distributed from a reservoir through 2½-inch and 3-inch pipe, to which a 2½-inch hose is attached every hundred feet for distributing the water.

Furrow irrigation is used for potatoes, and flooding down the slope for grass.

No. 4. P. B. Dilks has a 3-acre irrigated farm near Philadelphia, the water being supplied by a pumping plant. A triplex double-acting pump delivering 50 gallons per minute is driven by a 4-horsepower gasoline engine. Water is lifted 14 feet and forced through 600 feet of 2-inch pipe. The plant is usually operated twelve hours per day, in which time 1 acre is irrigated to a depth of 1.3 inches. Sometimes only half this depth is used. The engine is not loaded to its capacity and consumes but 2 gallons of gasoline in twelve hours. The engine and pump cost $500, pipe and hose $300, making the total cost of the plant $800. Two-inch piping costs 20 cents per foot.

The crops irrigated are celery, cabbage, and lettuce, and in very dry seasons beets and radishes. The entire flow of the pump is turned into one furrow, and takes ten to thirty minutes to run through. The furrows vary in length from 200 to 350 feet and are 2.5 feet apart. Occasionally the ground is sprinkled to kill lice on the celery or lettuce. Celery is irrigated once a week in dry weather, requiring three to four irrigations in a season. In dry weather irrigated celery and cabbage gave excellent yields, while unirrigated crops were a failure. Irrigated lettuce was 75 per cent better than unirrigated. One acre of celery will bring on an average $300, and 1 acre of cabbage $400, the price usually received for cabbage being $1 per barrel. Cabbage is irrigated in dry weather only when heading. The owner estimates that this single irrigation fully doubles the yield, and that the value of the celery crop is also doubled by irrigation.

No. 5. M. V. Dilks, on an adjoining farm, irrigates an acre of truck with water from the city waterworks. The flow is about 18 gallons per minute and the cost of the water $30 per year.

No. 6. Alfred Paul, of Montgomery County, irrigates one-half acre of strawberries with water from a spring, applied by the furrow system. The net returns from the crop were $250. Irrigation is said to double the value of the crop, and in 1905 it would have been a failure without water. Water is applied during the night, the irrigation season lasting only about two weeks. The total cost of developing the water supply was $50.

No. 7. U. J. Wieand, of Lehigh County, has a pumping plant for 4 acres of strawberries and potatoes. The plant consists of a 5-horsepower motor taking its power from a trolley line, and a No. 2 centrifugal pump delivering 165 gallons per minute against a 24-foot lift. It takes twenty-four hours to irrigate the 4 acres by the furrow system, making a depth of 2.2 inches. Mr. Wieand intends to install a 15-horsepower motor for the irrigation of 100 acres to be planted in rye, hay, and potatoes. He estimates that the irrigation season for potatoes would last six weeks.

No. 8. John F. Weaver, of Northampton County, irrigates 3.5 acres with water raised by a No. 6 ram. During extreme dry weather the supply is sufficient for 1.5 acres, and occasionally for 2 acres additional. Water is supplied to the ram under a 20-foot head and is elevated 185 feet to a tank of boiler iron 4¼ by 8 by 7 feet. The ram is fed through 160 feet of 2½-inch pipe and discharges through 2,000 feet of 1¼-inch pipe into the tank. The standpipe is 550 feet from the ram, which fills the tank in six hours, corresponding to a flow of 2 gallons per minute. The 1¼-inch pipe is buried in wooden chips and sawdust to prevent freezing. The water is distributed by hand sprinkling and by a four-arm revolving sprinkler, which is moved every half hour or hour. The tank full and the supply of the ram will irrigate one-quarter acre in twelve hours by the latter method. Tomatoes, cabbage, and beans are irrigated occasionally; celery, lettuce, and radishes are irrigated about every seven days in dry weather. Lettuce and Lima beans receive 4 irrigations, radishes 3, cabbage 1, and celery 12 in a dry season. It takes six weeks to raise lettuce and five weeks to raise radishes when the ground is irrigated just before planting.

Irrigation doubles the tomato and cabbage yields in average seasons, and in 1905 without irrigation there would have been no crop of lettuce, Lima beans, or celery. One-third acre of lettuce yielded in two crops 12,000 heads, which sold for from 2 to 8 cents apiece, the average price being 4 cents. An acre of radishes brought $750 in three crops in 1905, the price being 5 cents per bunch retail and 3 cents wholesale in a dry year. The wholesale price in average years is 1¾ cents per bunch. Early cabbage is planted 16 inches apart in 2½-foot rows. In 1904, 5,000 plants yielded 200 barrels. In 1905, owing to insufficient water supply, the yield was only 150 barrels. Tomatoes yielded 1,200 baskets per acre, the price in average years being 20 cents per basket. In 1905 the price was $1.25 per basket. Beans are irrigated from April through September. In 1905 the celery raised by irrigation was the finest ever grown on the place in size and weight. A bunch of twelve plants weighed 16 pounds, which at the price obtained, $5 per 100 pounds, made the yield per acre worth $1,000. The owner believes that besides hastening it irrigation doubles the crop.

The total cost of the plant, including ram, pipe, and 1,500 feet of additional 1¼-inch pipe used for the distribution of the water and the ¾-inch and 1-inch hose used, was $850. The cost of labor is 75 cents per day and board, and the irrigation of an acre requires six days.

No. 9. Ed C. Schafer, Northampton County, irrigates 4 acres with water pumped by a No. 8 hydraulic ram fed through 75 feet of 3½-inch pipe. The water supply for the ram is under 11-foot head and the discharge is elevated 80 feet through 575 feet of 1¼-inch pipe into a cistern 8 by 8 by 8 feet, which is filled in eight and one-half hours, corresponding to a flow of 7½ gallons per minute. Water is distributed by 1,000 feet of 1¼-inch and 1-inch pipe with T's for outlets every 40 feet. The land is watered by sprinkling, partly by hand, but principally by the use of a small water witch fed by 1-inch hose. This will cover a circle 30 feet in diameter and in seventeen hours will irrigate one-half acre, being moved every hour. It delivers 3½ gallons per minute. One hundred feet of 1-inch hose is used, half of which is replaced each year. The cost of the plant was $180, of which the ram cost $40, the feed pipe $15, and 1,000 feet of 1-inch and 1¼-inch piping $125.

Lettuce planted in June is sold in August, bringing in 1905 6 cents a head. Unirrigated lettuce did not mature. Radishes planted in April were harvested June 1. In 1905 they sold for 5 cents per bunch; in 1904, for one-half or one-third as much. Radishes, lettuce, and beets were irrigated every two days. Onions and cabbages were not irrigated.

No. 10. Julius Karabinus, of Northampton County, irrigates 7 acres of meadow land and 1 acre of truck from a creek across which a concrete dam has been constructed at a cost of $340. The dam is 84 feet long, with an average height of 4 feet. It is 4 feet wide at the base and 1 foot on top, with a rock foundation. It is provided with flashboards for raising the water level when desired, and has a wooden apron in front to take the impact of the water. Water is diverted through a ditch 4 feet wide and 2 feet deep, which carries about 4 cubic feet per second, a sufficient quantity to irrigate 400 acres in the arid region. No fixed system of irrigation was used, the water being distributed by wild flooding, some parts of the land being greatly overirrigated.

From one-half acre of truck 3,000 head of cabbage brought $90, and 20 bushels of cucumbers brought $20. Truck land was irrigated every other day; meadow land continuously. The owner believes that the profits of irrigation will soon pay the cost of the dam.

No. 11. J. F. Engler, of Northampton County, irrigates an acre of meadow land which in 1901 was planted in potatoes, yielding 80 bushels under irrigation. Unirrigated potato land yielded 90 to 100 bushels per acre. The land was irrigated by the furrow system every two weeks, the water flowing continuously for two days at a time in furrows 450 feet long. The crop undoubtedly suffered from overirrigation, resulting in decreased yield. In 1905 the yield from irrigated grass land was 2½ tons per acre, while unirrigated yielded 1½ tons per acre. In 1904, 1 acre of irrigated wheat land yielded 36 bushels, while unirrigated land of the same nature yielded 28 bushels.

No. 12. Harry Broadhead, of Monroe County, irrigates one-quarter acre of beets with water obtained from springs. The water runs into six 50-gallon barrels, which are used as reservoirs, whence it flows to the farm through 500 feet of 1-inch pipe, the vertical head being 30 feet. The land is watered by means of a water witch fed through a $\frac{3}{4}$-inch hose. The water witch covers a circle 20 feet in diameter, and is moved every half-hour. Water is applied once a week in dry weather. The water stored in the barrels and the flow of the spring is sufficient to operate one water witch for $3\frac{1}{2}$ hours. The owner thinks that irrigation has doubled the value of crops in average years.

On a farm near East Stroudsburg, at the time of the writer's visit, the celery crop had been set out only a short time, and was burning up in spite of attempts to irrigate by hauling water a short distance in a barrel. The time required was one hour per barrel. Eight barrels of water, holding 32 gallons each, or 34 cubic feet in all, were applied in two irrigations to one-quarter acre. This would correspond to a depth of 0.02 inch per irrigation, which is not sufficient to be of any advantage whatever. Figuring the time of a man and team at 32 cents per hour, the water cost $10 per 1,000 gallons, or over $3,000 per acre foot. This case is cited to show the folly of this method of irrigation except in setting out plants.

No. 13. R. F. Schwarz, of Monroe County, irrigates 5 acres of truck with water obtained from a spring on a sidehill near his farm. A timber dam 25 feet long forms a reservoir for the spring, from which the water runs to the farm through a half mile of 2-inch pipe, under a head of 150 feet. Part of the tract is irrigated every day and part every other day. With a flow of 10 gallons per minute, $1\frac{1}{2}$ acres can be irrigated in twenty-four hours. The furrow system is used, a hose supplying water to the ends of the furrows. Sometimes the ground is sprinkled, a large round sprinkler with small holes being used.

The crops irrigated are celery, cabbage, beets, lettuce, asparagus, raspberries, strawberries, radishes, and rhubarb. Cabbage is planted 15 inches apart in rows 2 feet apart. It sold in 1905 for 5 cents per head wholesale, and 6 to 8 cents retail. Celery was planted 6 inches apart in 3-foot rows. It sold for 5 cents per stalk, three-fourths of the crop maturing. Lettuce was planted 6 by 9 inches. In 1905 it brought 5 to 7 cents per head, and four crops were grown. Without irrigation it would be impossible to raise lettuce. Three crops of radishes were raised on the same land, spaced 7 inches apart. The cost of the entire system was $200. In dry years irrigation pays many times the interest on the investment.

No. 14. M. Garrahan, of Luzerne County, irrigates 9 acres in celery with water pumped from a slough, with a direct-acting steam pump driven by a 15-horsepower portable steam boiler. The fuel used is anthracite coal, costing $4 per ton. The fuel consumption in ten hours, the usual length of run, is 800 pounds. Labor costs $1.50 per day. The pump operates against a vertical lift of 13 feet, and delivers water into a $2\frac{1}{2}$-inch pipe 900 feet long, provided with outlets for distributing the water over the farm. The pump is said to deliver 150 gallons per minute and will irrigate the entire farm in one hundred and twenty hours, giving a depth of about 4 inches. The soil is a yellow clay 8 inches deep, with a tough clay subsoil.

The methods of irrigation employed are flooding by hose and sprinkling, the latter being used when it is necessary to get over the ground rapidly and flooding when more time can be allowed and more thorough irrigation is desired. The irrigation season lasts from June 1 to October 31, the land requiring at most three irrigations per year. In 1905 up to August 1 celery had received one spraying and one irrigation. In dry weather celery is irrigated every two weeks. Twenty-eight thousand plants are raised per acre. It requires twenty-four hours' pumping to spray the 9 acres, two men being employed two days, giving a depth of 0.9 inch.

The cost of the boiler and pump was $400. Two thousand six hundred feet of 2½-inch pipe used for the distribution of water cost 14 cents per foot. Twelve valves cost $3 each, and 400 feet of linen 2-inch hose, rubber lined, cost $160, bringing the total cost of installation to $960.

Irrigated celery sold at $1.50 per dozen bunches, each bunch containing 3 to 4 stalks. On unirrigated land in 1905 part of the celery did not mature, and bunches of 6 stalks each sold for $1.25 per dozen. The value of the crop from the 9-acre farm was $6,000. The ground was heavily manured in 1905, 60 tons of manure and 1 ton of fertilizer, costing $45, being used per acre.

No. 15. Mrs. R. C. Shannon, of Northumberland County, irrigates 2¼ acres, 1½ acres of which are planted in celery and the remainder in other truck. Water is pumped from a well dug 60 feet deep and bored 20 feet farther, water standing about 18 feet from the ground. A hot-air engine pumps water into two tanks, each 7 feet in diameter and 8 feet deep, which the pump will fill in six hours. Celery is irrigated every five days in dry weather by the furrow system.

No. 16. W. J. Suter, of Northumberland County, irrigates 2 acres of clay loam with water pumped by a small ram and a windmill. The ram lifts the water 40 feet through 1,200 feet of 1-inch and 1¼-inch pipe, delivering a flow of about 1 gallon per minute. The windmill is 8 feet in diameter and will deliver about one-half this flow. It pumps from a well 4½ feet square dug 26 feet deep. The normal level of the water in the well is 3 feet below the ground. In dry seasons a rate of delivery of 3,000 gallons per day will exhaust the well. The windmill pumps into a tank holding 1,500 gallons, set 20 feet above the ground. The water is distributed by piping and the ground irrigated by a sprinkler, a tankful being sufficient to water one-eighth to one-fourth of an acre. The land is irrigated in dry weather every two weeks, the season lasting from May to August. Crops never receive more than four irrigations per year.

Labor costs $1.20 per day and it requires one day to irrigate one-half of an acre, only one-fourth of the time of one man being consumed in moving the sprinkler. The yield per acre of celery brings on an average $1,600, and of lettuce, of which two crops are raised, $1,600 for both crops. The value of irrigated land is over $400 per acre, and of nonirrigated land $10 to $100 per acre. The owner estimates that irrigation is worth to him at least $500 clear gain a year. The cost of the plant was $450, of which the well cost $100, the windmill $100, the pipe $100, ram and pipe $50, and labor $100.

An earth tank built on a hillside for use in irrigation would not hold water, owing to the nature of the soil.

No. 17. C. McWilliams, of Northumberland County, irrigates 1½ acres from a creek. Water is stored in an earth tank with a capacity of 180,000 gallons. Water is taken from the reservoir by a 2½-inch supply pipe 250 feet long, from which 1½-inch feeders branch out for the irrigation of the land. Hose is used to supply water to furrows. About 6 feet of head forces the water through the pipes and delivers a flow of 10 gallons per minute, which requires eighteen minutes to flow through a furrow 320 feet long. This rate of flow will irrigate one-half of an acre in twelve hours. The irrigation season lasts from May to the middle of October, the land being irrigated every two to seven days in dry weather.

The value of the yield per acre is $450. On an average, irrigation increases the value of the crops $70 an acre. Although 1905 was a wet year, no other property in the vicinity gave as good crops of beets, lettuce, and celery. The value of unirrigated land is $50 per acre. The owner estimates the value of irrigated land at considerably over $100 per acre. The total cost of reservoir and plant was $200.

NEW JERSEY.

The New Jersey Experiment Station at New Brunswick has made many interesting irrigation experiments, the results of which are published in bulletins of this office.[a] Water for irrigation is obtained from the city mains and applied by the furrow system, the ground during dry weather being watered every seven days. The usual depth of irrigation is 2 inches. The experience here shows that in humid climates light irrigations are preferable, since a heavy rain following an irrigation is liable to swamp the land.

No. 18. F. W. Kilbourne, of Middlesex County, irrigates 2 acres of truck from the New Brunswick city waterworks at the rate of $1 per thousand cubic feet. From two to three crops are grown on the same ground, each crop usually receiving one irrigation and occasionally two. The furrow method of irrigation, with a hose, is employed, the rate of flow from the hose being about 10½ gallons per minute. The furrows are 240 feet long and 3 feet apart, and it requires thirty minutes for the water to run through them, on the average. It requires forty hours to irrigate 1 acre of ground, the cost for water being $3.30. The soil is a heavy loam 12 inches thick with a red shale gravel subsoil. In 1905 water did not cost over $25, and the total cost of pipe and hose was only $25.

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[a] U. S. Dept. Agr., Office of Experiment Stations Buls. 36 and 87.

Prizetaker onions yielded 900 bushels per acre. Three crops of lettuce of 50,000 plants per acre for each crop are usually grown on the same land, selling wholesale at from 2 to 6 cents a piece. Early cabbage is planted 15 inches apart in rows 2½ feet apart, giving 14,000 heads per acre. One acre of beets yielded 7,000 bunches, bringing 5 cents per bunch. Thirty thousand stalks of celery were planted per acre, yielding 8,000 bunches, 3 to 4 stalks per bunch, selling at 12 cents per bunch. Spinach is seldom watered. Irrigation fully doubles the crop on an average and in 1905 saved the crops from failure.

No. 19. W. P. Stokes, of Burlington County, a florist, formerly irrigated his gardens with a pump driven by a 2½-horsepower gasoline engine. The water was distributed by pipes and the furrow system of irrigation used. The pump was set in a pit 28 feet deep and obtained its supply from three 2-inch driven wells 53 feet deep. The last few years the rainfall has been ample and the plant has not been used for irrigation. A system of subirrigation has been tried, a line of inverted U-shaped tile being placed on boards about 15 inches below the ground. The soil is so sandy that this was unsuccessful, as the water all sank out of sight before reaching the end of the tiling.

No. 20. Henry A. Dreer, of Burlington County, irrigates 5 acres of land by water pumped from a dug well 8 feet in diameter and 15 feet deep. The well is lined with brick and cost, complete, $200. The water normally stands 5 feet below the ground level, and it is not lowered more than 1 foot at the highest rate of pumping. A duplex steam pump raises the water from the well into a system of distributing pipes. The pump is provided with an automatic regulator, which, by throttling the steam supply, holds the pressure in the mains constant at 50 pounds, forcing the water into a 3-inch main 700 feet long, from which it is distributed through the field. Horizontal pipes are run parallel to the rows every 50 feet, the length of the pipes being from 250 to 750 feet. These pipes are run about 3 feet above ground and are set on 2 by 4 inch wooden supports 20 feet apart. They are tapped for small brass plugs every 4 feet, the holes for the plugs being all in line. Each of these plugs has a pin hole in the center, which serves as an outlet for the water. The overhead pipe line is connected by a union to the supply pipe in such a manner that it can be easily turned at any angle. A valve admits water to each pipe. Each line is supposed to water 25 feet on either side, and after one side is watered the pipe is revolved until the streams of water are at the proper angle for watering the other side. The water by the time it reaches the ground is in the form of a fine spray.

The 250-foot lengths of pipe are composed of 100 feet of 1¼-inch pipe, 75 feet of 1-inch, and 75 feet of three-fourths-inch pipe. The 750-foot lengths are composed of 320 feet of 1¼-inch pipe, 240 feet of 1-inch pipe, and 190 feet of three-fourths-inch pipe. The small brass plugs, as well as the special drill provided with spirit level for boring holes in the same so as to have them in line, are both patented. The drill with spirit level sells for $10 and the brass plugs for 3 cents each. The measured discharge from one brass plug was 0.3 gallon per minute. In normal operation, one line of pipe will irrigate a space 50 feet in width in nine hours' run. This would correspond to a depth of irrigation of 1.3 inches. At its normal rate of operation, the pump is used to supply 9 lines 250 feet in length, or 2,250 feet of pipe, or 2½ acres. This would correspond to a rate of flow from the pump of 169 gallons per minute. If desired, the pump could be run at double this capacity. All pipe in use throughout the plant is galvanized. The well water being clear, no trouble has yet been experienced with the small outlets in the brass plugs stopping up.

The irrigation season lasts from the middle of April to the middle of October. The crops irrigated are flowers and strawberries. In dry weather they receive an irrigation every ten days, but they usually require not more than three irrigations per season. Irrigation is carried on, as a rule, between 7 p. m. and 4 a. m., in order to avoid scalding the crops and baking the ground. From 1.1 acres of irrigated land, where 91,000 plants were set out, 89,600 good potted plants were obtained, and from unirrigated land in former seasons not over 60,000 plants. As the value is $25 per thousand, this represents a gain of about $750 from irrigation.

No. 21. T. R. Hunt, of Hunterdon County, irrigates 6 acres planted in celery, strawberries, cabbage, and potatoes. The land was not irrigated in 1905, the pump cylinder having been cracked by freezing. A 3-horsepower gasoline engine drives a double-acting pump, delivering 30 gallons per minute. Water is taken from a pond and elevated 20 feet, the discharge pipe being 2 inches in diameter and 400 feet long. The cost of the engine was $225 and the cost of the entire plant $600. One and one-half gallons of gasoline are sufficient to operate the plant for ten hours.

The soil is a clay gravel loam 12 inches in depth, with a clay subsoil. The furrow system of irrigation is used, the furrows being 350 feet long and 3½ feet apart. The furrows are run on a steep grade and the flow from the pump divided between five furrows, requiring three and one-half hours to run through them. The pump will irrigate one acre in ten hours. Handmade canvas hose is employed for carrying the water down hill, under very light pressure. Muslin 1 yard in width is cut up into three strips, each of which is made into a hose, which is then dipped in a mixture of coal tar and oil. The water is admitted by short hose to the ends of V-shaped wooden troughs, from which it is admitted to the furrows by means of adjustable sliding gates. (See fig. 1.) The troughs are built of 1 by 5 and 1 by 6 inch boards nailed together and provided with 1¼-inch holes. There are three holes in these troughs for every two furrows, the intermediate one being used to supply additional water to either furrow should it be necessary.

Onions are seldom irrigated. In dry weather celery is irrigated every two weeks, receiving, at most, three irrigations per season. Strawberries usually receive one irrigation per season. In 1902 irrigation saved the entire strawberry crop from destruction. In 1905 without irrigation 3 acres of strawberries yielded 22,000 quarts, which sold for $2,200. In 1903 irrigated strawberries produced a fine crop, while unirrigated berries were a failure. In dry seasons the same thing is true of celery.

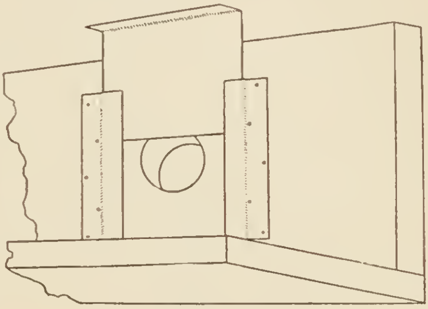

FIG. 1.—Sliding gate in flume.

No. 22. David Astle, of Cumberland County, irrigates 1.6 acres of land from two wells 6 inches and 3 inches in diameter and 47 feet deep, which were bored by a hydraulic process. The 6-inch well cost $168 and the 3-inch well $1.35 per foot, or $62. Surrounding the wells is a brick pit 8 feet in diameter and 16 feet deep, dug at a cost of $25. The brick walls are laid 4 inches thick, the brick costing $30. The total cost of the plant was $1,200. The water stands 23 feet below the ground level, and is hardly lowered by pumping. The water-bearing stratum consists of coarse sand and gravel.

The 6-inch well has a strainer 16 feet long and the 4-inch well a strainer 3 feet long. A 5-horsepower gasoline engine drives, through a countershaft, two double-acting power pumps at 35 revolutions per minute. One of these pumps has the suction side directly connected to the casing of the 3-inch well and the other pump has its suction pipe inside the 6-inch casing. The pumps deliver water into the same discharge pipe, which is 3 inches in diameter and 300 feet in length. The water is raised 44 feet above the ground level at the pump house into a wooden tank with a capacity of 2,000 gallons. The tank can be filled in thirty minutes. The cost of the tank was $40 and of the supporting frame $25. The plant consumes $3\frac{1}{2}$ gallons of gasoline, at $13\frac{1}{2}$ cents per gallon, in a ten hours' run. The water flows back through 300 feet of the supply pipe and then through 800 feet of 2-inch pipe to the land. This 2-inch pipe has an outlet every 22 feet, to which a hose can be connected for supplying a movable pipe with water.

The soil is a light sandy loam 8 inches deep, with a clay and gravel subsoil. The plant will usually irrigate 1 acre in two days' run, or twenty hours. The ground is irrigated by sprinkling from several water witches set 10 feet apart on a movable length of 2-inch pipe, which is mounted every 20 feet on 2-wheeled carriages. Eleven water witches are mounted on 100 feet of pipe supported by four carriages, as shown in figure 2, and will irrigate, without moving, a space 110 feet by 10 feet. Normally the water witches are run twenty minutes in the same place, but when necessary they are run for as long as an hour. Being mounted on wheels, the apparatus may be easily moved. In the driest seasons it has never been necessary to give the ground more than three thorough irrigations.

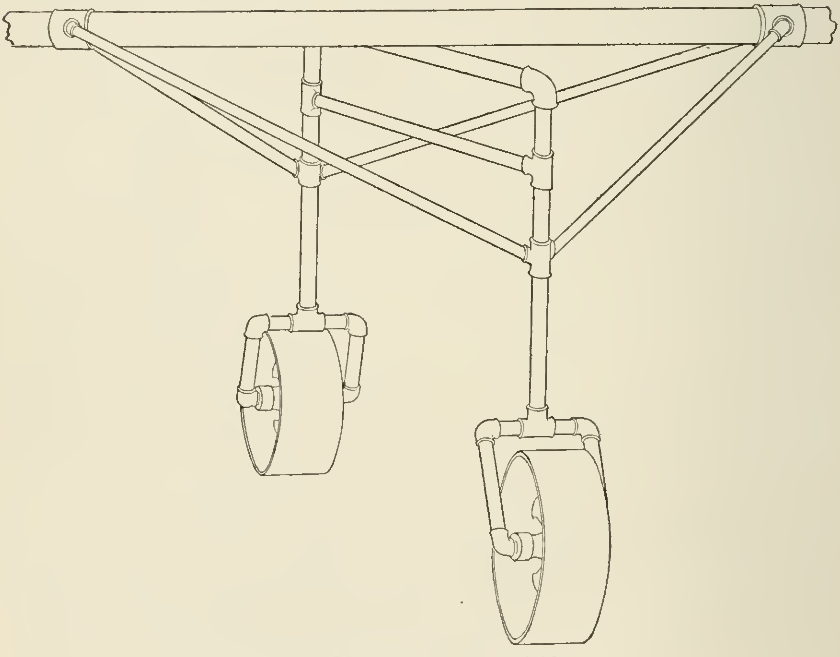

FIG. 2.—Carrier for pipe and sprinklers.

The value of the yield from an acre of celery is $1,200; unirrigated celery in 1903 was a total failure. In 1904 the crop from $1\frac{5}{8}$ acres of potatoes, irrigated once, brought $275, and was two weeks ahead of unirrigated potatoes, and, although it was a good year, yielded twice the crop. For one irrigation of potatoes 15 gallons of gasoline, at 13½ cents, were used, and six days' labor, at $1.50, or a total cost of $11. In some years irrigation will increase the potato crop fourfold.

No. 23. Cuno Becker, of Cumberland County, formerly irrigated a small tract of land by water pumped from a 2-inch driven well 45 feet deep, the water standing 24 feet below the ground level. A power pump driven by gasoline engine was used to force the water into an elevated wooden tank, which supplied water under 15 pounds pressure to parallel rows of 2-inch pipe running over the land. These rows were 10 feet apart, and on each was mounted a series of thirteen water witches 10 feet apart. Fifteen minutes is sufficient to wet the ground reached at one setting to a depth of 1.6 inches of water. Lawn sprinklers were tried, but required too much labor to move them and too much walking over wet ground. On irrigated land every strawberry ripened, and the berries brought 4 cents per quart more than unirrigated berries, not over half of which matured. Irrigated beets, lettuce, and cabbage were of much finer quality than unirrigated.

No. 24. The State Asylum for Feeble-minded Children, at Vineland, irrigates 10 acres by pumping from wells and 6 acres with sewage. Three 4-inch bored wells 122 to 157 feet deep supply all the water for irrigation and other uses. The wells are provided with 3-inch strainers 10 feet long, and the water stands 20 feet below the ground. A pump raises the water into a 50,000-gallon steel tank set 120 feet above the ground. The normal capacity of the pump is 150 gallons per minute. The boiler plant used for driving the pump is employed for heating in the winter time.

The land is irrigated by the furrow system, the furrows being 400 feet long and 3½ feet apart. The water supply from the tank is led through a pipe to a ditch at the head of the furrows. The plant will irrigate 3½ acres in a half day. The irrigated land will grow two or three crops of truck a year. Fifty thousand gallons of water are used to irrigate 3 acres of land, giving a depth of 0.6 inch. In 1905 irrigated potatoes yielded 271 bushels per acre, receiving but two irrigations, the season being wet. In dry weather the land is irrigated every week. Irrigation will, on the average, add one-third to the potato crop. A man and horse can prepare 6 acres a day for irrigation.

The sewage output of the farm is about 50,000 gallons per day, and is pumped through 250 feet of 4-inch pipe and elevated 6 feet by a 3-inch centrifugal pump driven by a steam engine. It discharges into a cistern holding 20,000 gallons, whence it runs through 500 feet of terra-cotta pipe and is distributed over the land by wild flooding. Only a part of the sewage is at present employed for the irrigation of 3 acres of fruit and 3 acres of beans.

No. 25. William Ash, of Cumberland County, irrigates 3½ acres, one half acre of which is under glass. The water is pumped from a dug well 3½ feet square and 15 feet deep, curbed with wood and brick. The well was sunk at a cost of $16. Water stands 5 to 13 feet below the surface. A 2½-horsepower gasoline engine drives two double-acting pumps, which deliver 60 gallons per minute to a line of 2-inch pipe 900 feet long. Three gallons of gasoline, costing 16 cents per gallon, are consumed in a ten hours' run.

The soil is a light sandy loam 10 inches deep, with a sandy clay subsoil. The sprinkling system is used, with four lines of ¾-inch pipe, each of which has three water witches 17 feet apart. The ¾-inch pipes are set in the field from 14 to 18 feet apart and are connected to a 2-inch main by not to exceed 60 feet of ½-inch hose. Normally the sprinklers run for one-half hour in a place, though sometimes an hour. The plant will irrigate 1¼ acres in a twelve hours' run, during which it will take about one-fourth of a man's time to attend to the irrigation and move the pipes. The cost of labor is $1.50 per day. The maximum lift against which the pump operates is 18 feet. The total cost of the plant was $700, the engine costing $150.

From two to three crops are grown on the same land, the spring crops consisting mainly of cauliflower, radishes, beets, and cabbage, and the fall crop of lettuce. Irrigation will fully double the crop in average seasons. The following table shows the yield of the various crops and the frequency of irrigation:

Irrigated crops near Vineland, N. J.

Crop.	Yield per acre.	Rate.	Value.	Maximum irrigations per crop.	Irrigation season.
Beets.................... bunches..	20,000	3½ cents per bunch.	$700	3	May 20 to June 20.
Cabbage.................. heads..	12,000	$1 per barrel.	350	4	Do.
Cauliflower................ do....	12,000	$1.50 per barrel.	750	6	May 20 to July 1.
Radishes............... bunches..	20,000	5 cents per bunch.	1,000	2	
Lettuce.................... heads..	51,000	....	1,000	6	Aug. 15 to Oct. 1.

In the driest weather crops are irrigated not more than twice a week, sprinklers being allowed to run for one hour in the same place. Five hundred and fifty bushels of potatoes were raised on an acre of good rich irrigated truck land and 300 bushels on an acre of poorer soil. One acre of unirrigated land, the soil of which was better than the second plat of irrigated potatoes, yielded 90 bushels.

No. 26. George Mitchell, of Cumberland County, has an irrigation plant of sufficient capacity to irrigate 10 acres of truck land. The water comes from a small creek near the farm, across which a small dam has been erected. In dry weather, when the supply from the creek is insufficient, the storage afforded by the dam will supply the pump for three hours. A 2½-horsepower gasoline engine drives a No. 2 centrifugal pump delivering 110 gallons per minute against a total lift of 15 feet. The discharge pipe is 4 inches in diameter and 500 feet long. The engine consumes 3 gallons of gasoline in ten hours.

The furrow system of irrigation is employed, the furrows being 4 feet apart and 600 feet or less in length, set on a grade of 1 foot per 100 feet. The entire supply is usually turned into two furrows, requiring fifteen minutes to run through. One man can irrigate an acre in four hours. The cost of labor is $1.25 per day. The owner estimates that the cost per acre for fuel and labor is $1 for each irrigation, the depth applied being ½ to 1½ inches.

Sweet corn is irrigated if dry at the time the ears are setting, or if needed, while the ears are growing. In a good year unirrigated sweet potatoes will yield from 100 to 300 bushels per acre. They are commonly planted May 20 and harvested in October. September is the most important season for the irrigation of sweet potatoes, a single irrigation in September having increased the value of the sweet potato crop $40 per acre.

No. 27. J. H. Shute, of Gloucester County, irrigates 1 acre of land, planted in truck and strawberries, with water pumped from a 1¼-inch driven well 25 feet deep, provided with a strainer 4½ feet long. The cost of the well was $14. The water stands 14 feet below the ground level. A hot-air engine drives a double-acting pump, which lifts the water into a wooden tank 31 feet above the ground. The tank holds 2,000 gallons and the pump will fill it in seven hours. An 8-foot windmill is also used for pumping from the same well. The hot-air engine uses kerosene for fuel, at a cost of 7 cents per gallon. In a ten hours' run the engine consumes 2 gallons of kerosene.

The soil is a dark waxy loam 12 inches deep, with a clayey gravel subsoil. The furrow system of irrigation is employed, water being supplied to the furrows through a hose. The furrows are 100 feet long and 3 feet apart. Water is furnished to the field through 1¼-inch and ¾-inch pipes. The irrigation of an acre of ground will usually require 6 tanks of water, giving a depth of 0.35 inch. It requires two days to irrigate 1 acre. The cost of the plant was $455, of which the engine cost $130, the windmill and pump $125, the tank $150, and the pipe $50.

Celery is irrigated twice a week in the driest weather, receiving at most 15 irrigations per year. Onions are irrigated every two to three days and yield 600 bushels per acre. In 1903 the crop from one-third of an acre brought $250 and would have failed without irrigation. On the same land during the same year 60 barrels of onions, at $2.40 per barrel, had previously been raised, making $394 from one-third of an acre of land.

No. 28. L. M. Parkhurst, of Atlantic County, irrigates 3 acres from a 3-inch bored well 50 feet deep. The well is provided with a 6-foot strainer, and the water stratum is gravel. The water stands 23 feet below the surface. The cost of the well was $50. A No. 8 hot-air engine drives a pump delivering 8.3 gallons per minute. The total lift of the water is approximately 26 feet. The fuel used by the engine is kerosene, purchased at 9½ cents per gallon, and in twenty hours' run the fuel consumption is 7 gallons. The plant cost $350 and used 5 barrels of kerosene in 1905. Water is pumped into an earth reservoir 22 feet square on top and 4 feet deep, lined with 1-to-1 cement 1 inch thick. The construction of the reservoir required one foreman, two field hands, and one team for four days, making a labor cost of about $25. It is fairly tight, though the lining is cracked in a few places.

The furrow system of irrigation is commonly used, though occasionally land is watered by hose. The furrows are 400 feet long and 4 feet apart. The discharge from the reservoir is turned down one furrow, through which it flows in about thirty minutes. It requires five hours to irrigate one-half an acre, using one reservoir full, or a depth of about 0.9 inch.

The ground is a black waxy loam 7 inches deep, with a gravel subsoil. The ground is irrigated in dry weather once or twice a week. Strawberries receive at most three irrigations. Two acres in strawberries yielded in 1905 4,000 quarts per acre, while unirrigated land yielded but 2,800 quarts per acre. Potatoes, which received one irrigation in 1905 rather late in the season, yielded one-fourth larger crop than unirrigated potatoes. Irrigation will in general increase the yield from one-third to one-half.

No. 29. Herman Graumann, of Atlantic County, irrigates 10 acres planted to strawberries and truck, from three 2½-inch driven wells 22 feet deep, the water level in which is 16 feet below the ground. The wells, which are located far apart, cost $15 each to drive and are pumped by means of a portable 2½-horsepower gasoline engine, which drives a double-acting power pump, delivering 33 gallons per minute. The pump and engine, which are mounted on the same truck, are hauled from well to well, as required, and the water discharges through a 3½-inch canvas hose from 50 to 1,000 feet in length, whence it is distributed over the land by spraying. The pump will irrigate one acre in four hours.

The soil is a sandy and waxy loam 12 inches deep with a gravelly clay subsoil. Truck is irrigated every seven days; strawberries every one or two days in the driest weather. Strawberries are watered by furrows 80 feet long and 4 feet apart, and it takes the water twelve minutes to flow through. Two men are required to operate the pump and distribute the water. Irrigation in dry years increases the return from strawberries at least $100 per acre. The plant cost $270, of which the engine cost $200, the pump $60, and the truck $10. The hose is a second-hand fire hose and cost the owner nothing.

The cost of well boring in this vicinity is as follows:

	Per foot.
1¼-inch well	$0.50
2-inch well	.75
3-inch well	1.50–1.75

No. 30. John I. Sickles, of Monmouth County, irrigates 6 acres in truck and strawberries with water pumped from a brook by an 8-foot windmill mounted on a 50-foot tower. Water is pumped through 14 feet of 1½-inch pipe and elevated 30 feet to a tank holding 6,000 gallons. A 1½-inch main with branches of ¾-inch pipe 200 feet long and 75 feet apart, provided with taps for ¾-inch hose, distributes water over the land. The cost of the entire system was $1,600.

The soil is a light sandy loam. The land is irrigated by sprinkling. The water witches used will cover a circle 20 feet in diameter and are allowed to run for twenty-five minutes in the same place. Strawberries are irrigated at night by the furrow system and in dry weather are watered every night. Truck is irrigated in dry weather every one or two days, the irrigation season lasting from March to October.

By the aid of irrigation three crops can be grown on the land. In 1905 three crops were grown on unirrigated land, but average years yield about a crop and a half. Irrigation increases the yield of strawberries and peas 50 per cent and matures radishes ten days earlier. Beets were two weeks earlier when irrigated. The results with cabbage were not good, probably owing to the ground being insufficiently tilled. In very dry weather radishes were raised by irrigation in twenty-one days from the time of planting.

No. 31. Julius Roehrs, of Bergen County, has an extensive system of hothouses irrigated with water from the city mains at a cost of $1.40 per thousand cubic feet.

No. 32. William Young, of Essex County, irrigates 12 acres of truck with water pumped from an 8-inch well 406 feet deep, which cost $2.50 a foot. The water stands 24 feet below the ground and is lowered 2 feet when the pump is in use. A vertical 15-horsepower boiler supplies steam under 65 pounds pressure to a direct-acting steam pump, with 2½-inch suction and 2-inch discharge, delivering 65 gallons per minute. The vertical lift is 30 feet. The fuel is soft coal, costing $4.25 per ton, about 30 tons being used in one year. The plant is usually operated for twelve to fifteen hours a day. Five thousand feet of 2-inch pipe are used in distributing the water over the farm. Several lengths are coupled together with unions 40 feet apart. Every 20 feet is a T, from which a half-inch pipe 6 feet long rises vertically, on top of which is a water witch. The line of sprinklers is connected by a hose to 2-inch mains running through the farm. These mains are taken up in winter. The pump will operate twenty-one water witches, which are run for an hour and a half in one place for a thorough irrigation, after which the pipe is moved in sections a distance of 25 feet. It takes three men fifteen minutes to move and set up a line of twenty-one sprinklers.

The soil is of a black waxy consistency 1 foot deep, with a clay subsoil. It requires one hundred hours to irrigate 12 acres. In dry weather truck is irrigated every week. The crops grown consist of celery, cabbage, cauliflower, beets, and radishes. Two crops a year are usually grown.

No. 33. F. J. Forthuber, of Essex County, irrigates 15 acres by pumping from a creek. A 20-horsepower vertical boiler supplies steam under 70 pounds pressure to a duplex steam pump with a 4-inch suction pipe 50 feet long and a 3-inch discharge pipe 1,200 feet long, with outlets 50 to 100 feet apart. The vertical lift is 70 feet, but the water pressure usually carried at the pump station is 70 to 100 pounds. Hard nut coal, at a cost of $4.25 per ton, is used for fuel, the consumption being 500 pounds in ten hours. The annual consumption is 6 to 12 tons. Water witches are mounted on ¾-inch pipe rising vertically from a 1½-inch pipe line. The water-witch line is connected with unions every three lengths (60 feet). The pump supplies twenty water witches, which are spaced 20 feet apart, and it takes three men fifteen minutes to move a line of twenty. If the land is very dry they are run in the same place for an hour. This irrigation is repeated the next day, and after that once or twice a week. The pump delivers 150 gallons per minute and will irrigate 1 acre in ten hours, giving a depth of about 3.5 inches.

Lettuce, celery, and other kinds of truck are irrigated not over six times per crop, starting in May. Celery and lettuce are the crops most improved by irrigation.

The total cost of the plant was $2,000, and the owner estimates that in 1902 irrigation increased the value of the crops $1,000. For the last two years it has been of no material benefit and is said to do considerable harm when followed by heavy rains.

No. 34. Henry Schumacher, of Morris County, irrigates 10 acres of truck from the city waterworks, paying $1.50 per thousand cubic feet. A 1¼-inch main is run through the farm for a distance of 600 feet, with taps 100 feet apart. Six water witches on half-inch pipe are mounted 15 feet apart on a section of 1¼-inch pipe. With the usual pressure they will irrigate a space 15 feet wide. Three men are required to move the line of witches, which are run one-half hour to an hour in the same place. Eight hundred feet of ¾-inch hose, costing 8 cents a foot, is used, in lengths of 200 feet or less. The pipe laid in the ground cost $100, the water witches, etc., $25, and the hose $64, making the total cost $189.

The soil is a dark loam 12 inches deep, with clay subsoil. One acre can be irrigated in twenty hours with six sprinklers, one set of sprinklers being run at a time. It takes one day's labor at $1.25 to irrigate an acre of land. Crops are irrigated in dry weather every two weeks, receiving at most three irrigations in a season. Water is not applied in the heat of the day, but usually at night.

The average cost of water is $100 per year. The price of land in this vicinity is high, due largely to its speculative value. Two crops are grown in a season. Irrigation sometimes saves the entire crop from failure, and the owner estimates that the value of the crops, which averages $1,000 per acre, is increased 40 per cent by irrigation, which insures better quality and earlier crops.

No. 36. Arthur Robinson, of Hudson County, irrigates 2 acres from the city waterworks, paying $1.50 per thousand cubic feet. Three water witches 9 feet apart, connected together by a hose, are mounted on a wooden frame 18 feet long provided with two runners, so that it can be easily dragged about. This is fed by a $\frac{3}{4}$-inch hose connected to a 1-inch main running through the farm. The water witches irrigate a space 10 feet wide and run twenty or thirty minutes in the same place. One man can easily move them. They use 1,000 cubic feet in a twelve-hour run. The owner estimates that irrigation doubles the yield in average seasons. Celery and cauliflower are watered once a week in very dry weather.

No. 37. W. Gurnheit, of Hudson County, irrigates 15 acres in truck with water from the Hackenside Water Company, at a cost of $1.40 per thousand cubic feet. A 2-inch main runs through the farm, provided with 1-inch branches every 100 feet. These branches are provided with $\frac{3}{4}$-inch valves every 20 feet. Four sprinklers, mounted on vertical pipes 10 feet apart, extending upward from the $\frac{3}{4}$-inch pipe, are operated at the same time. These will irrigate a space 10 feet wide. They are usually run for an hour in the same place. Three-quarter-inch hose, in lengths up to 150 feet, is used to connect the pipe line with the water-witch line. In dry weather the crops are watered once a week. The annual cost of water is about $150. Radishes are not so sensitive to overirrigation as spinach, lettuce, and beets.

There are about 50 irrigated farms in the vicinity of Seacaucus using similar methods of irrigation. Nearly all obtain water from the same company.

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No. 38. F. Schumacher, of Queens County, irrigates 15 acres of truck from a spring. The supply is reinforced by three 2-inch driven wells 40 feet deep, in which the water rises and flows into the spring.

The pipe for the wells cost 15 cents a foot, and the cost of driving the three wells was $5. A 4-horsepower vertical boiler supplies steam at 40 pounds to a duplex pump, which delivers 75 gallons per minute through 1,200 feet of 2-inch pipe, against a 60-foot vertical lift into a wooden tank holding 12,000 gallons. The fuel used is hard coal, costing $6 per ton, 5 to 8 tons being used in a season. In a twelve-hour run 250 pounds of coal is burned. One man is required for the operation of the steam plant. A 10-foot windmill, supplied from a 2-inch well, is also used to pump water into the tank. It pumps against a total lift of 75 feet.

The soil is a light sandy loam, 12 inches deep, with a clay subsoil. Sprinkling from water witches is usually employed, although occasionally furrow irrigation is used. The water supply will irrigate 1 acre in eighteen hours. The water witches are mounted on ¾-inch pipe 3 feet high, which rise vertically every 10 feet from T's on a 1-inch pipe, which is 190 feet long, making twenty water witches on the line of 1-inch pipe. The sprinklers are run for half an hour or more in one place and will irrigate a strip 10 to 14 feet wide. The entire sprinkler pipe line is moved by six men in one minute. Thirty-five hundred feet of 2-inch pipe and 500 feet of inch hose are used in distributing water over the farm. The cost of the entire plant was $1,500. The 2-inch hose cost 11 cents per foot and the tank $95.

In dry weather most truck is irrigated every week. Lettuce is irrigated every two to three weeks. The owner believes that irrigation is worth $1,000 in average years. In one year the crop from a single acre of irrigated lettuce sold for $1,000, while unirrigated lettuce failed entirely. Potatoes and onions are seldom irrigated.

No. 39. Phillip Bach, of Queens County, irrigates 7 acres in truck from five 2-inch driven wells, 20 feet deep, costing $28 apiece. The water stands 10 feet below the surface. A vertical boiler supplies steam to a duplex pump, delivering 80 gallons per minute, against a vertical lift of 67 feet, through 1,200 feet of 2-inch pipe into a wooden reservoir holding 10,000 gallons. A 12-foot windmill furnishes an additional supply. The pump will fill the tank in two hours. Four hundred pounds of hard coal, costing $5 a ton, is used in a ten-hour run.

The soil is a sandy loam, 3 feet deep, with a clay subsoil. The pump will irrigate 1 acre in ten hours. The water is distributed over the farm through a 2-inch main with 1¼-inch branches 150 feet apart. These branches are provided with 1-inch outlets 75 feet apart, to which a series of water witches is connected by hose. The water-witch lines, three of which are used at a time, consist of 6 sprinklers, each mounted on ⅜-inch pipe, which rise vertically every 12 feet from a 1-inch pipe. The water witches will irrigate an area 14 feet wide. Three men can move the water-witch line in two minutes. Not over

50 feet of hose is employed in making the connection from the pipe line. In ordinary irrigation the water witches will run in the same place for one-half to three-quarters of an hour. In dry weather crops are irrigated every week, receiving not over twelve irrigations in a season. Three thousand feet of 2-inch pipe is used. Two to four crops are commonly grown on the same land. The total cost of the plant was $1,200.

No. 40. Witte Brothers, of Queens County, irrigate 18 acres from a 6-inch well, 88 feet deep, provided with a 3-foot strainer. The water-bearing stratum is sand. The water stands 18 feet below the surface and is lowered to 36 feet by pumping. The cost of the well was $380. A 4-horsepower vertical boiler supplies steam at 20 pounds to a deep-well pump set vertically over the well. The total lift of the water is 61 feet. Hard coal, costing $6 a ton, is used for fuel, the annual consumption being 10 tons. In fifteen hours the plant burns 4 bushels, or 325 pounds of coal.

The soil is a sandy and waxy loam 12 inches deep, with a clay subsoil. The main for distributing the water is a 2-inch pipe with 1-inch outlets. Both hose and water witches are used. Four water witches mounted on ½-inch vertical pipes are supplied by a 1-inch pipe line. It requires two men to move the sprinkler pipe line. The water witches are 14 feet apart and water a tract 14 feet wide. They are run in the same place 1½ hours. The pump will operate eight sprinklers and one 1-inch hose, and will in addition fill the tank in fifteen hours.

Cauliflower and cabbage are usually watered with the hose every three days in dry weather. Lettuce and celery are sprinkled once a week. The hose will water one acre in five hours, using about as much water as five sprinklers. The distance from the tank to the power house is 1,000 feet. The plant contains 2,800 feet of 2-inch pipe and cost $2,500.

No. 41. B. H. Mohlenhoff, of Queens County, irrigates 3 acres with city water. The price charged for water for this and adjacent plants is $3 for the first thousand cubic feet, $2 for the second, and $1 per thousand for all additional water used within six months. A 1½-inch main provided with ¾-inch valves is run through the farm. Three or four water witches 18 feet apart are attached to one section of 1-inch pipe by ⅜-inch vertical pipes and will irrigate a space 18 feet wide. They are usually run in one place for three-quarters of an hour. Not over 200 feet of hose is employed. Three men are required to handle the water-witch line. In dry weather the land is irrigated every week. The water is considered rather cold for irrigation, and the pressure is considered too low for the sprinklers.

No. 42. August Plenge, of Queens County, irrigates 4 acres with city water. Five water sprinklers are operated from a 1-inch water-witch line. The water witches are mounted on ⅜-inch vertical pipes 8 feet apart and will irrigate a space 9 feet wide. They run one-half hour to an hour in the same place, and it requires three men to move the line. Three-quarter inch hose in lengths up to 300 feet is employed to feed the water-witch line. Two-inch and 1½-inch pipe, provided with 1-inch valves 30 feet apart, supply the farm.

The soil is a light sandy and waxy loam 7 inches deep and is inclined to bake after irrigation. Truck is irrigated every week in dry weather. The total cost of the plant was $400. The annual cost of water is $100 Irrigation has paid well, and in 1905 was particularly useful in starting crops.

No. 43. John Schumacher, of Queens County, irrigates 4 acres of truck from the city waterworks. Five water witches are mounted on ⅜-inch vertical pipes connected to a 1¼-inch water-witch line, which it requires four men to handle. The water witches are 16 feet apart and water a tract 16 feet wide. They run from thirty minutes to an hour in the same place. The main is 2-inch pipe with 1¼-inch branches. The total cost of the plant was $750, and the annual cost of water is $100. The value of the land in this vicinity is $1,000 per acre.

Truck is irrigated not more than twice a week in the driest weather. Irrigation doubles the value of the crops in average seasons. Two to three crops per year are commonly raised on the same land, and in dry seasons irrigated land can grow one crop more than the land not irrigated.

No. 44. Bender Brothers, of Queens County, irrigate 17 acres of truck with water from the pipe line of the Bowery Bay Improvement Company, at a cost of $1 per 1,000 cubic feet. Five sprinklers mounted 16 feet apart on ⅜-inch vertical pipes are usually operated from the same line. Three to four lines are operated on the farm, requiring four men to move them. The water witches irrigate a space 16 feet wide and run on the same piece of land from one-half hour to an hour. They are supplied through a 1-inch connection and a ¾-inch valve, the water supply being under 80 pounds pressure. Twenty-five hundred feet of 2-inch main is employed in distributing the water over the farm, and ¾-inch hose is employed in lengths up to 600 feet. The land is irrigated every week or two in dry weather.

The total cost of the plant including the meter was $830, of which $150 is for hose. The annual cost of water on the farm is $125. As a rule water is applied from the latter part of the afternoon until midnight. The owner says that irrigation doubles the value of hotbed crops—lettuce and soup greens. The plant will irrigate 12 acres of land in six days. Labor costs $1 to $1.25 per day, and $18 to $20 per month, with board.

No. 45. The largest irrigated farms investigated were in the vicinity of Boston. Frank Coolidge, of Middlesex County, irrigates 100 acres of truck land with water pumped from several open bottom wells 2½ to 4 inches in diameter and 20 to 30 feet deep. The water in the wells stands 9 feet below the surface and is lowered 2 feet when pumping at full capacity. The boiler plant, which is used for heating in the winter, consists of three 14-foot horizontal boilers, supplying steam at 90 pounds to two direct-acting steam pumps. Water is delivered at a pressure of 85 to 100 pounds. The plant uses 2½ tons of soft coal in ten hours, one man attending to the plant. The plant is usually operated from 7 a. m. to 6 p. m., although occasionally when the weather is very dry it is run twenty-four hours.

One and one-fourth inch rubber hose is used in lengths of 100 feet, with fan-shaped nozzles. The combined capacity of the pumps is sufficient for 8 nozzles. The hose is fed through 1¼-inch valves placed every 60 feet in the distributing pipe. The piping is all laid on top of the ground and is taken up in the winter. The distributing pipe where it leaves the pumping station is 4 inches in diameter, and it reduces in size at various parts of the farm down to 1¼ inches. The large pump is sufficient to supply five hose streams and the smaller pump three.

The soil consists of a light sandy loam 10 inches deep, with a sandy subsoil. One man with a hose can irrigate 0.9 acre in a day. Occasionally water is distributed in furrows, the quantity of water used being twice as great as when the hose is used. The furrows are 50 to 150 feet long, averaging 6 feet apart. Two to four crops are usually grown on the same land in a year, and sometimes five. Irrigation sometimes saves the loss of an entire crop. The cost of the plant was about $7,000.

No. 46. W. W. Rawson, of Middlesex County, irrigates 40 acres by pumping from 4-inch open bottom wells 85 feet deep. Three pumping stations have been installed for supplying water, in each of which is a 4-inch well and a 48-inch by 13-foot horizontal boiler, which supplies steam under 60 pounds pressure to a steam pump. The well water stands 10 feet below the ground and is lowered 6 feet when the pumps are operated at 50 strokes per minute, delivering 55 gallons per minute each. The maximum total lift is 40 feet. The water flows through 1,000 feet of 4-inch and 1,000 feet of 3-inch main pipe. The laterals used are 2½ inch and 1¼-inch pipe. Each plant consumes 1 ton of soft coal at $4, in a twelve-hour run. Forty to 50 tons are burned in the three plants in a season. The cost of labor is $1.75 per day. The total cost of the plant was $3,000. The hose sprinkling system is usually employed. Sometimes the furrow system is used, each pump supplying two 2½-inch hose streams. Two hundred gallons per minute will furnish four hose streams, each of which will irrigate an acre in a day.

The soil is a sandy loam 2 feet deep, with a sandy subsoil. The ground is irrigated in dry weather every week to a depth of 1 inch. City water, costing $1.10 per 1,000 cubic feet, was used to the extent of $1,000 in 1905 instead of pumped water. It is often impossible to raise crops without water. On the average irrigation will increase the yield one-third.

No. 47. Weyman Brothers, of Middlesex County, irrigate 40 acres of land with water pumped from a dug well 10 feet deep, in which the water stands 5 feet below the level of the ground. The land is located near a lake, and the water level in the well is not lowered appreciably by pumping. A 25-horsepower horizontal boiler furnishes steam to a duplex pump, which is run at 75 strokes per minute. Soft coal, costing $4.50 per ton, is used. The plant consumes one-half ton in ten hours.

The pump delivers water either into a reservoir or direct into the mains. The reservoir is 40 feet in diameter and 11 feet deep, built of stone with cement-lined walls, and fills in seven hours. The reservoir gives a pressure at the farm of 15 pounds per square inch. When pumping direct into the mains the pump will supply twelve 1-inch hose streams through a 4-inch main 450 feet long. Movable branches of 2½-inch pipe, provided with outlets 56 feet apart, may be attached every hundred feet. One-inch hose distributes water from these outlets, the greatest length of hose employed being 150 feet.

The present plant is suitable for about 20 acres and is being enlarged. The plant is operated about thirteen hours a day and supplies the reservoir twice a week. The land is watered every three days in the driest weather. Furrow irrigation is used to a limited extent. The owner values irrigation as an insurance and says it doubles the crop at times and sometimes increases it only a third.

No. 48. James Purcell, of Middlesex County, irrigates 10 acres from the city waterworks. The main consists of 2-inch and 1¼-inch pipe, from which branches of 1-inch and 1¼-inch pipe run out 100 feet apart, provided with outlets every 100 feet for 1-inch hose used in lengths of 50 feet.

The soil and subsoil are sandy, and one stream of water will irrigate one-half acre in a day. Truck is watered every week in dry weather. The annual cost of water for irrigation is $100.

No. 49. W. H. Allen, of Middlesex County, has several farms near Arlington irrigated by pumping and from the city mains. One farm of 15 acres is irrigated by city water at $1.10 per thousand cubic feet, or about $400 annually. The method of irrigation was mainly sprinkling by hose. Where the furrow system is used the furrows are 300 feet long. The soil is all sandy. One stream of water will irrigate one-half acre in a day. Three to four streams at a time are used on this farm.

For another farm of 35 acres water is obtained by pumping from a well. A steam pump delivers water against a 15-foot lift, through 2½-inch pipes. This plant burns 800 pounds of coal in twelve hours. Seven men are employed on this farm, one man for running the pumping station and six for watering the land. Irrigation doubles the yield of eggplant and almost doubles the yield of other crops. Without irrigation it would be impossible to raise celery.

On a third farm 45 acres of land are irrigated by pumping and from the city mains. A 15-horsepower vertical boiler supplies steam to a duplex pump, which delivers water into the main under 70 pounds pressure. The plant uses 700 pounds of soft coal in twelve hours. This plant supplies four hose streams and the city waterworks three, the cost of city water being 75 cents per thousand cubic feet. At times fifteen men are employed in the irrigation of this farm, the work being carried on day and night.

When the land is irrigated by sprinkling, which is the usual method, one man will irrigate one-half acre in a day. The water issues from the sprinkler in the form of a cone, the sprinkler being provided with an adjustable cone plug in the center for varying the size of the opening, as shown in figure 3. Part of the land is irrigated by the furrow system, using 2 to 2½ inch streams of water. One man operates each stream, irrigating an acre in a day.

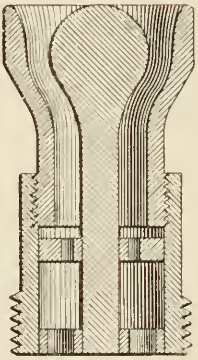

Fig. 3.—Adjustable nozzle.

No. 50. The Hittinger Fruit Company, of Suffolk County, formerly irrigated several acres from a hillside spring. A 150,000-gallon brick and cement-lined reservoir was supplied from an 8-inch bored well 254 feet deep, cased 45 feet. The water stands 6 feet below the ground, but when pumping 40 gallons per minute it is lowered 150 feet. Overhead revolving sprinklers were formerly used for distributing the water; but as there was considerable trouble from the holes stopping up from rust, the system was given up. A ground line of 1½-inch pipe was connected every 30 feet with 1¼-inch vertical pipes, each having a 1-inch horizontal pipe attached.

A more satisfactory arrangement, made of 2-inch pipe, is shown in figure 4. It is provided at the end with connection for a 2-inch hose, to which is attached a one-half to five-eighths inch nozzle. The horizontal pipe was 20 feet long and was provided with a counterbalance and a swivel to turn about the vertical pipe. The pipes were spaced 150 feet apart, and this arrangement was found quite satisfactory. One day's labor was required to irrigate 1 acre. The furrow system was used for strawberries, the furrows being 150 feet long and 3 feet apart. One hundred feet of 2-inch hose was employed for this purpose. In a dry year the strawberry crop was doubled. The greater part of the farm is now devoted to fruit trees, and irrigation has been practically abandoned.

No. 51. C. H. Slade, of Suffolk County, irrigates 10 acres by pumping from a dug well 15 feet deep, the water standing 6 feet below the ground. A boiler, which in cold weather heats a greenhouse, furnishes steam to a direct-acting pump which delivers water against a 75-foot lift into a 10,000-gallon wooden tank, which it fills in eight hours. The water for the tank is pumped through 500 feet of 2-inch pipe. The hose system of irrigation is used. A $\frac{3}{4}$-inch hose will empty the tank in ten hours, and in this time will irrigate 1 acre of land to a depth of 0.4 inch. The water is used largely in greenhouse irrigation, a hose and sprinkler being employed. Cucumbers are irrigated every day in dry weather. This plant cost $1,000, including tower and tank.

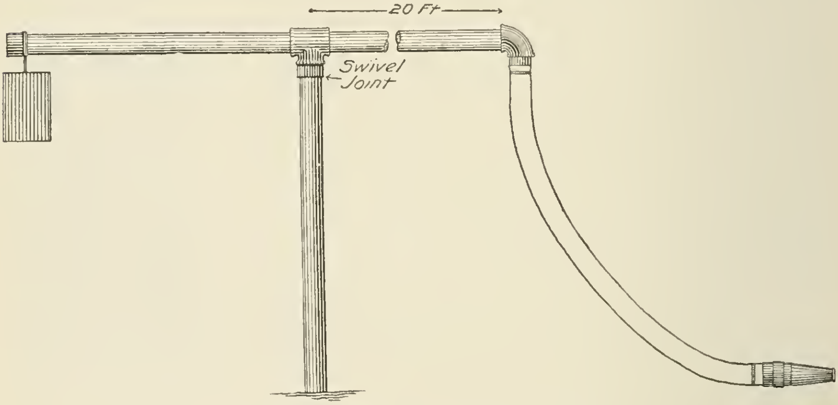

Fig. 4.—Adjustable hydrant with hose and nozzle.

The same owner irrigates 12 acres by pumping directly into a 3-inch pipe line, provided with T's for hose connection every 300 feet. The pump will supply a 2-inch hose stream. Hose is used in lengths up to 300 feet and the water is distributed by sprinkling. This plant cost $600, and uses $\frac{1}{3}$ ton of coal, at $4.50, in a day. In 1905, 5 acres were irrigated. The pump will irrigate 1 acre in two days to a depth of 4.5 inches. The great difference in the depth required inside a greenhouse and in the field shows very clearly the effect of the glass cover in preventing evaporation.

No. 52. A. H. Long, of Suffolk County, irrigates 1 acre with city water, costing $1.20 per thousand cubic feet. The water is distributed by sprinkling from a single water witch, the annual cost of water being $100. The sprinkler will cover a 20-foot circle, and is run for half an hour in the same place. The owner estimates that in 1905 irrigation was worth at least $200 an acre to him, increasing the yield about one-third.

On a farm near by 5 acres were formerly irrigated by pumping from four driven wells 2 inches in diameter and 20 feet deep. The cost of the plant, which consisted of a 25-horsepower boiler and a No. 6 pump, delivering 28 gallons per minute, was $500. Five hundred pounds of soft coal, at $4.50, were used in twelve hours. The water was supplied to the farm through 500 feet of 3-inch pipe and 100 feet of 2½-inch fire hose, the full flow requiring twelve hours to water an acre to a depth of 0.7 inch. The annual cost of fuel and labor for operating the plant was $250. The cost of labor is $1.50 per day.

No. 53. H. W. Locke, of Middlesex County, irrigates 10 acres of celery and cabbage from the city waterworks. A 1½-inch main pipe distributes the water under 25 pounds pressure to ¾-inch hose. The pipe is run on top of the ground and moved as desired. One man can water an acre in a day. As a rule irrigation is used only for planting and shortly afterwards, although occasionally four or five irrigations are applied. The cost of water averages $75 a year. Irrigation frequently saves the crop.

No. 54. Lovell Brothers, of Middlesex County, irrigated 2 acres of celery for the first time in 1905, using water from the Metropolitan Water Company, at the factory rate of 20 cents per thousand cubic feet. The water is distributed by means of ¾-inch hose. The soil is clay and does not require so much moisture as the sandy soil of surrounding farms. The land was irrigated for planting only. One man irrigated half an acre a day.

No. 55. Pierce Brothers, of Middlesex County, irrigate 6 acres from the city waterworks, using a 1¼-inch main, provided with outlets every 75 feet for ¾-inch hose. The furrow system is also used occasionally, the furrows being 300 feet long and 6 feet apart. The flow from the hose will irrigate one furrow in an hour.

The soil and subsoil are a gravelly loam. Crops are irrigated every three or four days in dry weather, each crop receiving from five to ten irrigations. From one to three crops are grown on the same ground. In a dry season it would be impossible to grow crops without irrigation, and in average seasons irrigation increases the yield of the land fully 25 per cent. The cost of water is $100 per year.

No. 56. James W. Russell, of Middlesex County, irrigates one farm at Winchester and another near Medford. On the first farm 5 acres are irrigated with city water, costing $1.50 per thousand cubic feet, with a discount of 50 per cent for every 1,000,000 gallons (134,000 cubic feet) used in a year. In 1904 and 1905, 5 acres were irrigated. The cost of water in 1904 was $60 and in 1905 $30.

Spinach, lettuce, corn, celery, and cauliflower are the crops irrigated. The town pressure is insufficient for the use of sprinklers, so the furrow system is used. The cost of irrigation equipment on the farm was $300. In dry seasons irrigation increases the yield from 20 to 50 per cent.

On the second farm 21 acres are irrigated from a pond, partly fed by two 2½-inch wells 50 feet deep, which flow when the pond is lowered by pumping. A portable 10-horsepower boiler and a direct acting steam pump are mounted on a wagon. At 90 strokes per minute the pump delivers 180 gallons per minute through 400 feet of 3-inch pipe, and through 2½-inch fire hose in lengths up to 1,200 feet. Rubber-lined canvas hose costs $1 per foot and lasts 10 years. The plant cost $1,700.

The furrow system of irrigation is commonly used, the furrows being 210 to 400 feet long and 4 to 5 feet apart. The stream from a 2½-inch hose is divided between 5 to 20 furrows, according to the grade of the land, the usual number being 7, in which event it requires twenty minutes to irrigate them. Four acres can be irrigated in an eleven-hour run. One man distributes the water, but it requires three men once a day to move the pipe. Bare land is irrigated for planting by attaching a 1-inch nozzle to the hose. Tender plants are watered with a ½-inch nozzle under high pressure, which makes a fine spray.

The soil is a sandy loam 7 to 12 inches deep, with a gravel and sand subsoil. The average lift does not exceed 10 feet, the pressure being mainly due to friction in the pipe. In a day's run of eleven hours, 500 pounds of hard coal, at $6.75 per ton, is used, the average annual consumption being 6 to 12 tons. The crops irrigated are dandelion, kale, spinach, corn, and celery. Celery is irrigated every two weeks in dry weather, receiving about four irrigations per crop. Sweet corn produces 300 bushels per acre, with about 60 ears per bushel. The corn is first harvested July 17. Irrigation increases the value of the crops 20 to 50 per cent, according to the rainfall. An increase of 50 per cent is obtained only when the rainfall is very light.

RHODE ISLAND.

No. 57. D. N. Potter, of Providence County, irrigates 22 acres in beets, lettuce, celery, and cucumbers from a pond. A duplex steam pump forces the water through 400 feet of 3-inch pipe and 1,000 feet of 2-inch pipe provided with 2-inch branches. The water is distributed by a 1-inch hose provided with ½-inch nozzles, the maximum length of hose employed being 200 feet. The supply is sufficient for two nozzles. In addition the greenhouse consumes 5,000 gallons of water in three hours. Part of the piping is buried, and the other part, which is laid on the surface of the ground, is taken up every winter. The ground is usually irrigated from 3.30 p. m. to 7 p. m. Four hundred pounds of soft coal, costing $4.10 per ton, is used in a ten-hour run, about 50 tons being used in a season.

The soil is a sandy loam 15 inches deep, with a light loam subsoil. One man will irrigate one acre in nine hours. In dry weather the land is irrigated not more than twice a week nor more than six times in a season. The total cost of the plant was $1,700.

Carrots, parsnips, rhubarb, corn, and beans are very seldom irrigated. Cucumbers in the hotbeds are irrigated every two days. Two to three crops are grown on the same soil. Irrigation will generally produce one extra crop, will make the crops much earlier, and increase the yield fully 25 per cent. Irrigation increases the value of the celery crop fully one-third.

No. 58. C. W. Patt & Son, of Providence County, irrigate 10 acres in celery from a creek. A vertical boiler supplies steam at 40 pounds to a direct-acting steam pump run at 40 strokes per minute. The water is forced under a pressure of 80 to 100 pounds into a 3-inch distributing pipe 800 feet in length which runs through the farm and is provided with outlets for 2½-inch hose. The land is irrigated entirely by one 2½-inch fire hose with a 1-inch nozzle. The hose is in 50-foot lengths. In irrigating one length is uncoupled and the nozzle is screwed onto the next every fifteen minutes without shutting off the water. Every forty-five minutes the hose is changed to another outlet on the main pipe line, the plant being shut down for fifteen minutes. The hose will irrigate one acre in an hour. Water is applied in dry weather every two to three days from June through September.

The soil is a sandy and heavy loam 18 inches deep, with an open subsoil. The fuel is hard coal, costing $6.75 per ton. In a ten-hour run 200 pounds are burned, and about 8 tons in a season. One man is required to operate the pumping plant. The owner estimates that the gain in the yield of celery is at least 25 per cent.

The same owners irrigate 22 acres planted in radishes, celery, lettuce, spinach, beets, and parsley. These crops are irrigated every week in dry weather, except celery, which is irrigated twice a week.

A 50-horsepower horizontal boiler supplies steam to a duplex pump, which draws its supply from a creek nearby and delivers water to a 3-inch main at 140 pounds pressure, the vertical lift being 32 feet. It is run at 60 strokes per minute and supplies five 1-inch hose streams. The suction-pipe is 5 inches in diameter and 550 feet long. The 3-inch main is 1,500 feet long and is provided with 2-inch, 1½-inch, and 1¼-inch branch pipes fitted with 1-inch hose connections with ½-inch nozzles. The greatest length of 1-inch hose used is 100 feet. One stream will irrigate one acre in three hours. One ton of soft coal at $3.40 will run the plant fourteen hours.

METHODS OF IRRIGATION.

Of something over 60 plants described in the preceding pages 25 use the furrow system, usually supplying water through pipes and hose, 17 use hose sprinkling, 8 use single water witches, and 18 use multiple water-witch systems. Twelve of these plants use more than one system, and about 10 are not reported. While the data are too variable to form a basis for reliable statements as to relative advantages, it is interesting to notice what averages the data show.

The size of a single stream of water averages 24 gallons per minute for each furrow, 44 for each hose nozzle, and about 4 gallons per minute for each sprinkler used. The time during which water is run in one place averages half an hour for the furrow system and nearly an hour with sprinklers. None of the plants using furrows or single sprinklers requires more than one man to look after the water, usually using not more than half of his time during an irrigation. Where hose sprinkling is used the entire time of one man is required for each nozzle during an irrigation, the average number of men being three. With multiple sprinklers, owing to the necessity of moving long lines of pipe, a number of men are required for a short time when the water is changed, only a small fraction of their time being taken for this purpose. The number of men required averages three, the work of irrigation taking about one-fourth of their time. Where a complete system of piping is installed, one man can look after an entire plant.

In estimating the labor cost of one irrigation, the actual time put in by each man must be considered. In the following averages labor is taken at $1.50 per day, and it is assumed that five minutes are required to change the water in a furrow or to move a sprinkler. Where multiple witches are used, five minutes are allowed for moving the first of a system of bars, and three minutes for each additional bar, except on the larger places where a number of men must be called from greater distances, in which cases ten minutes are allowed for the first bar. On this basis the labor cost of one irrigation by furrows runs from $0.30 to $1.20, averaging $0.75 per acre. With hose sprinkling the average is $1.80 per acre; with single witches, $1.12, and with multiple sprinklers $2.40, ranging in the latter case from $0.45 to $8.70 per acre. The depth applied, however, is 1.3 inches by furrows, 0.6 inch by hose sprinkling, 0.3 inch by single sprinklers, and 1.8 by multiple witches; making the average labor cost of applying 1 acre-foot of water, $7.10 by furrows, $34.80 by hose, $34.40 by single sprinklers, and $16.10 by multiple sprinklers, but where a complete system of pipes is installed the cost runs as low as $3.50 per acre-foot. It should also be noticed that the labor of applying water with sprinklers is not increased by lengthening the time and the amount of water used since only a definite number of changes are required to irrigate a given piece of land once. With hose or furrow irrigation the labor is proportional to the amount of water applied, and can only be decreased by increasing the flow of water handled by one man.

Owing to the interruption of other work, when a number of men must be assembled every hour or so to change the water, it is usually much better to arrange the distribution so that one man can use his entire time to good advantage. For instance, one farmer uses several bars of ¾-inch pipe 34 feet long, provided with three sprinklers each which one man can handle easily. Better work is likely to be done where one man devotes his whole time to irrigation. Where the water supply is not sufficient to require the entire time of one man, it would be well to arrange the system so that one man can do all the work when irrigation is required.

The reason for the prevalence in the East of the sprinkling method of irrigation, which is practically unknown in arid sections, lies in two important differences in the conditions of irrigation practice. First, the quantity of water applied in one irrigation in the East must be small, owing to the risk of sudden and heavy rains which would swamp a crop if falling soon after a heavy irrigation; and, second, the soils used for truck farming in the East are not, as a rule, so capable of storing and retaining water as the arid soils, so that a heavy irrigation once a month will not answer the needs of garden crops in the East. With the sprinkling system it is possible to apply uniformly as small a quantity of water as desired, while with furrows enough must be applied to run through the furrows and soak laterally to the roots of the plants.

In brief, the advantages of the sprinkling system are that there is no loss of space if the main pipes are laid underground, and no loss from leakage; it is applicable to uneven ground and hillsides, since water is delivered under pressure; no special preparation of the surface is required, and plants may be set as close as desired; a very small flow of water may be utilized, and a light irrigation may be very quickly applied in emergency. Its disadvantages are the great first cost for pipe and connections; the high pressure head which must be overcome when water is pumped; the excessive cost of city water where used; and the great expense of applying water and maintaining an elaborate system.

The advantages of the furrow system are its cheapness and simplicity, requiring only ordinary farm tools to lay out; the ease with which one man can handle a large stream of water; the fact that water is applied by gravity and need not be pumped higher than the land to be watered, dispensing with high storage tanks. Water may be applied at any time of day without danger of scalding the plants, since the foliage is not wet and evaporation from the ground surface is reduced to a minimum. The disadvantages are: The loss of space where head laterals are used, and the expense of piping, where pipes are used instead of open-head ditches; the cost of leveling and smoothing land so that the furrows may carry the water without flooding; the expense of furrowing out before each irrigation and of cultivating afterwards, and the necessity of planting far enough apart for horse cultivation; the difficulty of applying water evenly in very sandy soil, and the loss of water by seepage in head ditches, especially where the flow used is small.

In irrigating with a hose by hand many use no nozzle at all, simply putting the thumb over the end of the hose to make a fine spray. A cheap nozzle is often made by flattening the end of a piece of ordinary pipe. Others use a fine-hole sprinkler or some form of patent adjustable nozzle.

Where sprinklers are used, the simple forms shown in figures 5 and 6 are much in favor. One widely used type of water witch (fig. 6) consists of a small revolving device with two concave horns which revolve, owing to the reaction of the water flowing between them. These sprinklers operate with a pressure of 15 to 30 pounds, and will cover a circle 15 to 30 feet in diameter. Their simplicity and cheapness have led to their wide adoption. The water passages through the sprinkler are fairly large and not easily clogged. Many irrigators use small brass plugs with one small hole drilled in the center. Revolving-arm sprinklers are very little used, being expensive and too easily clogged.

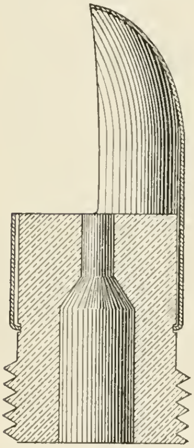
Fig. 5.—Simple nozzle.

The various arrangements of multiple sprinklers are described above in connection with the detailed data regarding truck-irrigation plants, and a few details are shown in figure 7.

Where pipe is laid on the surface, it is frequently taken up and stored away during the winter, making a great deal of labor. It is usually better to bury the pipes below the depth of cultivation, provision being made to drain the water out, so as to prevent freezing. In many cases there is a tendency to buy too small pipe for mains, which needlessly increases the pumping head, and thus the fuel cost.

THE COST OF IRRIGATION.

The cost of irrigation includes, besides the cost of applying water already discussed, both interest and repairs on the plant and fuel and attendance for pumping. Where city water is used the fuel and attendance are included in the rate paid for water. Interest and taxes may be taken at 7 per cent of the cost of the plant, and depreciation, repairs, and renewals at 13 per cent, or 20 per cent annually as the total fixed charges on small pumping plants. This expense is constant whether the plant is used or not.

Seven plants using city water irrigate 61 acres, the average cost of plant per acre being $44, while the cost per acre on individual plants varies from $12 on farm No. 18 to $188 on No. 44. The average fixed charges on the basis assumed are thus nearly $9 per acre annually.

Six gravity systems irrigate 15 acres, the first cost varying from practically nothing in Nos. 11 and 12 to $100 per acre in No. 6, where a supply had to be developed.

Seventeen pumping plants, irrigating 388 acres, cost an average of $74 per acre, the least cost being $27 for No. 29 and the greatest being $455 for No. 27. The average fixed charges may be put at about $15 per acre.

The cost of city water is quite uniform, averaging in fifteen cases $1.11 per 1,000 cubic feet, or about $48 per acre-foot. As the depth applied averages about 4 inches, the cost of city water per acre is $16.

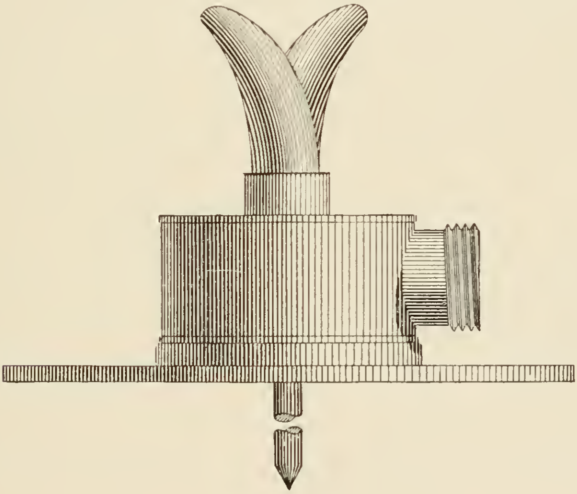

FIG. 6.—Nozzle.

The reasonable cost of pumping can hardly be determined from the small amount of data available, but comparison with skillful western practice shows that the expense is unnecessarily high, due to several causes. In most pumping plants in the West the amount of piping used is small, and the pressure against which the pump operates is practically the lift alone. In the East, with the pipe distributing systems, the friction head and discharge head are often far in excess of the actual lift, necessitating much larger power plants and fuel consumption. Any system of sprinkling requires at least 20 feet discharge head for hand sprinkling and twice as much for water witches, and larger heads are decidedly preferable. In any extended distributing pipe system there will necessarily be large friction losses in the pipe, since pipes large enough to cut down this loss would be too expensive.

The actual lifts of pumping plants in the East vary from 13 to 80 feet, while total pressure heads of 150 to 200 feet are not uncommon, and in one plant the pressure head was 340 feet, of which only 32 feet was actual lift. In other words, the power was eleven times that required to lift the water. On an average, the total head is probably three times the lift. Where elevated tanks are used, the work of pumping is often increased two or three times. In many places the power plant installed is fully six times as large as would be necessary were the water to be elevated only to the highest point of the ground to be irrigated.

Of twelve cases, the average of the cost per acre-foot for fuel and labor is $13.15 where steam power is used. Adding to this the fixed charges given above, the total cost of providing and distributing water, but not applying it, is $28 per acre-foot. A cost of $28 per acre-foot for water delivered at the point where it is ready to be applied to the fields is very high in comparison with western costs.

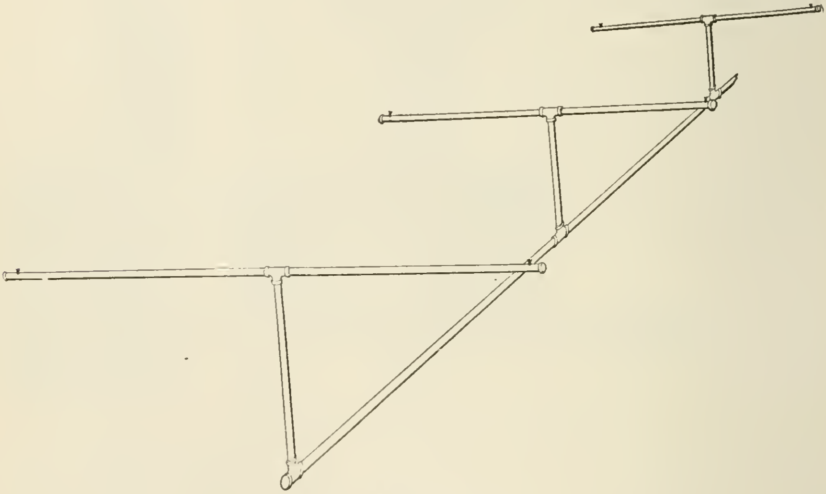

FIG. 7.—Multiple sprinkler.

In six plants using gasoline engines the average cost for gasoline per acre-foot pumped is $2.91, as against $6.18 for fuel alone for coal plants. This difference is due to the greater heads under which the coal plants operate—perhaps four times the average head for the gasoline plants—and to the use of direct-acting steam pumps, which are very wasteful of steam. Gasoline plants should be more widely adopted in the East, except where steam plants obtain their steam from boilers used for other purposes, such as heating in the winter time, and thus effect a saving in first cost over the gasoline plant. The average steam plant under the conditions observed costs over four times as much for fuel and attendance as the average gasoline plant.

In many cases the use of a reservoir holding from one to three days' supply of the pump would greatly facilitate irrigation. These reservoirs may be constructed by throwing up earth embankments, the inside slope of the embankment being 1 vertical to 2 or 3 horizontal and the outside slope 1 vertical to 1½ or 2 horizontal, the top of the bank being about 4 feet wide. The banks should be constructed as far as possible of water-tight material, such as clay or "puddle," and should be carried down to a water-tight stratum by means of a carefully filled ditch, which will thoroughly bind the bank to the original surface. If the material at hand will not hold water the reservoir must be lined. Concrete, asphalt, and tar mixtures are used for this purpose. Reservoir embankments, when suitable material for construction is near at hand, should be built for 15 to 25 cents per cubic yard in the East. To this must be added the cost of lining, if necessary. Cement will probably cost 10 to 15 cents per square foot laid 4 inches thick, and tar mixtures will be much cheaper.

RETURNS FROM IRRIGATION.

In a humid country it is especially hard to get at the probable returns from irrigation, owing to great variations in the distribution of rainfall, the nature of the soil and the subsoil, and to the effects of severe rains. For example, in a dry year unirrigated crops may be a total failure and irrigated crops be as large as ever, while in a wet year irrigation may prove a positive detriment. An estimate of the real value of irrigation should show the average results obtained during a period sufficiently long to give a fair average of climatic conditions. Only the State experiment stations are in a position to obtain reliable figures for long periods and to compare directly the results of irrigated and unirrigated crops. There is at present little reliable information on this question. Still the estimates of various farmers as presented in this report may give a better understanding of the problem and present a fair idea of the benefits to be obtained.

The average yearly value of truck crops in nine cases was given as $1,030 per acre, of which value the irrigators estimated that $330 was due to irrigation, or an increase of 47 per cent. Other estimates run usually 30 to 50 per cent. As the cost of irrigation usually lies between $30 and $100 per acre, it is fair to assume an average profit of $200 or more per acre due to irrigation.

In order to form some idea of the probable benefit of irrigating field crops, many farmers in Pennsylvania were asked the following questions regarding the various crops: What is the yield per acre in an average year, and what is the corresponding yield in seasons when the rainfall is ample? The replies have been compiled, and the averages are presented below as giving merely a preliminary indication of the possibilities of irrigation. Of course, damage by severe storms and frost would affect irrigated and unirrigated crops alike.

Comparative yields in wet and dry years.

Crop.		Average yield per acre.	Yield per acre in a wet year.	Assumed price.	Value average crop.	Increased value in good year.
Corn	bushels	48	64	$0.60	$28.80	$14.40
Wheat	do	20	28	.83	16.60	6.64
Rye	do	20	25	....	....	....
Oats	do	40	52	.37	14.80	4.44
Tobacco	pounds	1,330	1,700	.08	106.40	29.60
Timothy	tons	1.6	2.1	13.00	20.80	6.50
Clover	do	1.6	2.1	11.00	17.60	5.50

CONCLUSION.

The data presented seem to warrant the following conclusions:

The irrigation of meadows and truck farms is an established and profitable practice in the North Atlantic States, while the profitable irrigation of field crops has not been demonstrated as yet.

The methods employed are very expensive compared with western practice, but are the outgrowth of peculiar conditions and meet the requirement of very small applications of water.

The quantity of water required by truck crops either as rain or irrigation is about 1 inch in depth every week, and in the light sandy soils generally used it should be applied in quantities not exceeding 1 inch at a time.

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 168.

A. C. TRUE, Director.

THE STATE ENGINEER AND HIS RELATION TO IRRIGATION.

BY

R. P. TEELE,

Expert in Irrigation Institutions.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

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- Bul. 124. Report of Irrigation Investigations in Utah, under the direction of Elwood Mead, chief, assisted by R. P. Teele, A. P. Stover, A. F. Doremus, J. D. Stannard, Frank Adams, and G. L. Swendsen. Pp. 336.
- Bul. 130. Egyptian Irrigation. By Clarence T. Johnston. Pp. 100.
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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 168.

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THE STATE ENGINEER AND HIS RELATION TO IRRIGATION.

BY

R. P. TEELE.

EXPERT IN IRRIGATION INSTITUTIONS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., April 25, 1906.

SIR: I have the honor to transmit herewith a report on the State Engineer and his Relation to Irrigation, prepared by R. P. Teele, and to recommend its publication as a bulletin of this Office.

Respectfully,

A. C. TRUE,
Director.

HON. JAMES WILSON,
Secretary of Agriculture.

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THE STATE ENGINEER AND HIS RELATION TO IRRIGATION.

INTRODUCTION.

The office of State engineer is peculiar to the arid States, and the duties of the office have to do chiefly with irrigation. These duties range from merely making hydrographic surveys, as in Oregon, to practically complete control of the water supply, as in Nevada. It is true, however, that in most of the arid States whatever there is of public control of the use of water centers in the office of State engineer. A comparative study of the work of the engineers involves, therefore, the whole subject of public control of water.

The final purpose of the creation of the office of State engineer is the delivery of the water to which he is entitled to each farmer whose farm is under irrigation, and a necessary preliminary to this is a knowledge of how much each is entitled to. The early laws governing irrigation were not such as to provide a record of rights, and it is therefore necessary to provide means for defining existing rights. This in some States has been committed to the engineer, in others he makes surveys to assist the courts in this work, while in others he has nothing to do with it. To avoid future trouble, it is also necessary that hereafter rights be defined as they are acquired, and several States have provided that rights be acquired under the supervision of the engineer, while others still have no provision for supervising the acquirement of rights, but leave the defining of the rights to be done when controversy regarding them arises. The final act—the distribution of the water of streams to those entitled to it—is in some States all that devolves upon the engineer, while in some States the engineer has not this duty, but has a part in the proper defining of rights.

It is the purpose of this report to describe the methods used in the different States for accomplishing the three acts—defining existing rights, supervising the acquirement of new rights, and distributing water—and in exercising whatever additional control over irrigation exists, in the hope that this comparative study may bring out the strong and weak points in the different systems and help toward the adoption of the best methods in all the States.

In this report the States which have now or have had engineers are taken up in the order in which the office was created.

CALIFORNIA.

California was the first State to create the office of State engineer. A long series of discussions and proposals for different systems of public control of irrigation in California, which included National control and construction, State control and construction, and various other schemes, culminated in 1878 in the passage of a law creating the office of State engineer for the purpose of collecting information as to water resources and irrigable lands. The purpose of the law was "the acquirement of data upon which the State might formulate a policy and frame legislation respecting irrigation matters."[a] The office was continued for ten years, during which time there was much criticism on account of the lack of results, and in 1887 the legislature made an appropriation for salary and expenses for one year, with the proviso that this should be in full for the completion of all work then in the hands of the State engineer. Two large reports were issued, one on irrigation in Italy, Spain, and France, and one on San Diego, San Bernardino, and Los Angeles counties, Cal. Since the abolition of the office there has been more or less agitation for its revival, but in general the people of California seem to be quite indifferent on this matter.

Rights are acquired without public supervision and are defined only in case of controversy, and water is divided without any public supervision, the only remedy when one's rights are infringed being a suit to define rights if they have not been defined, and a proceeding for contempt of court if any party is taking water which has been allotted to another by the court.

COLORADO.

The office of State engineer was created in 1881, the engineer being given general charge of the distribution of water throughout the State. The same law provided for the defining of existing rights by the courts, and for filing claims for new rights with the county clerks and the State engineer, the idea being that this filing of claims would provide a record of new rights. The provision for filing claims was, however, declared void on account of a defect in the title of the act. In this plan the engineer is considered a purely administrative officer, and his duties, so far as they relate to irrigation, were confined to general supervision of distributing water after rights have been defined.

DEFINING RIGHTS.

Rights are defined by the courts in a special form of procedure prescribed by the statute. As a preliminary to this adjudication all parties claiming any interest in any ditch, canal, or reservoir were required to file statements of their claims with the county clerks before June 1, 1881. Since that date any party interested in any ditch, canal, or reservoir may apply for an adjudication of the rights to the source from which the water is taken. Upon the receipt of such application the court proceeds to an adjudication, usually appointing a referee to take testimony and formulate a decree defining the rights. The decree is based on the testimony presented by the claimants, as a rule, but in some cases the courts have employed engineers to measure the capacities of the ditches. Notices of the hearings are given by publication and by personal service on all parties having claims on file. Each party may call such witnesses as he chooses, but must pay their fees.

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[a] Wm. Ham. Hall's Rpt., Pt. 1, p. 12.

After hearing all testimony or on receiving the report of the referee, if one has been appointed, the court enters a decree "determining and establishing the several priorities of right, by appropriation of water, of the several ditches, canals, and reservoirs in such district, concerning which testimony shall have been offered, each according to the time of its construction and enlargement or enlargements or extensions, with the amount of water which shall be held to have been appropriated by such construction and enlargements or extensions, describing such amount by cubic feet per second of time, if the evidence shall show sufficient data to ascertain such cubic feet, and if not, by width, depth, and grade, and such other description as will most certainly and conveniently show the amount of water intended as the capacity of such ditch, canal, or reservoir in such decree."

The clerk of the court issues to the claimant a certificate of his rights as defined by the court, upon the payment of a reasonable fee, and these certificates are recorded by the county recorder upon payment of the customary fees. Appeal may be taken to the supreme court of the State at any time within four years, or any party may ask for a rehearing in the district court at any time within two years; but after four years from the entering of a decree "all parties whose interests are thereby affected shall be deemed and held to have acquiesced in the same, except in case of suits before then brought, and thereafter all persons shall be forever barred from setting up any claim to priority of rights to water for irrigation in such water district adverse or contrary to the effect of such decree."

Any party acquiring a right after the rights in any district have been decreed may have his rights defined by applying to the court which entered the original decree, the procedure being the same as for an original adjudication.

Most of the rights in Colorado have been defined under this special form of procedure, but there is continuously arising litigation to settle points which had not arisen at the time the decrees were rendered.

ACQUIREMENT OF RIGHTS.

In 1903 the law requiring filings by those building new works was reenacted, and since that time every party constructing or enlarging any ditch or reservoir is required to file with the State engineer a statement of his claim, with duplicate maps of the proposed works. The maps must be filed within sixty days of the commencement of construction, which may be the date of actual construction or the beginning of the survey. The duplicate is examined and certified to by the State engineer and is returned to the applicant, so that it may be filed with the county clerk within ninety days of the date of the beginning of construction. Maps must be on a good quality of tracing cloth, 24 by 36 inches, with a 2-inch margin on the left-hand side, making the available space for the map 24 by 34 inches. All maps are made of this size, irrespective of the size of the works, and must not be folded. In the case of reservoirs the scale must be 1 inch or more to 400 feet, and if necessary more than one sheet must be used. The map filed with a notice must show the location of the head gate, the route of the ditch, or the high-water line of the reservoir, and routes of the feeders and outlets from the reservoir, the legal subdivisions of land on which the works are located, and the names of the owners. Upon or attached to the map must be a statement showing the location of the head gate; the depth, width, grade, and length of each ditch, canal, or feeder proposed; the carrying capacity of each ditch in cubic feet per second; the time of commencement of work, and the estimated cost of the proposed project. For a reservoir the statement shows the height of the proposed dam, the estimated cost, the capacity in cubic feet, and the surface area for each foot in depth of water stored, up to and including the high-water mark.

The engineer is required to certify that he has examined and approved the map and statement "if he shall find the data therein contained to be sufficient and satisfactory for a clear presentation of the facts concerning the claims made."

As to the effect of the law requiring these filings: Up to September, 1905, 1,280 claims had been filed. There are about 1,000 filings made under the earlier law, which was declared void. Claims are at present coming in at the rate of about three per day. The legal effect of filing a claim is declared by the statute as follows:

> A certified copy of the map and statement thus filed in the State engineer's office shall be prima facie evidence in any court having jurisdiction of the intent of the claimant or claimants to make such construction, and to utilize such rights as are shown and described in the map and statement: *Provided*, That nothing herein contained shall be so construed as to dispense with the necessity for due diligence in the construction of such projects, or to the injury of those having rights prior to those of the claimants. (Laws of 1903, p. 291.)

This law makes the engineer a mere recording officer so far as the acquirement of rights is concerned. There is no inspection of works by the engineer to ascertain what is done under the claims, and no provision for filing of statements regarding this by the claimant.

The requiring of such filings may be regarded, however, as a step toward a better system which will provide for an inspection and measurement of the completed works and the submission of proof as to dates of beginning and finishing construction. Such proof, taken as soon as the works are done, when dates and capacities can be easily ascertained and made a matter of public record, will be of great service in providing a table of rights to all streams. But the application of the water appropriated to a beneficial use is necessary to the acquirement of a right, and there should be provision for the taking and recording of proof as to the use of water, as well as the construction of works.

DISTRIBUTION OF WATER.

Colorado was the pioneer State in providing for the distribution of water by public officials, the engineer being the head of the system. The State is divided into five divisions, the boundaries of which are determined by drainage lines, so drawn that each division is independent of all others, as no water flows from one to another. Each division is divided into districts, each of which includes a tributary or a section of a stream, the idea being to make the districts of the sizes which will make the distribution of the water easiest. For each district there is a commissioner, who has direct charge of regulating the head gates of the ditches in such a way that the water will be justly distributed among those having rights to its use. For each division there is a division engineer, who has supervision of the water commissioners of the districts within his division, while the State engineer has supervision over the entire matter of distributing water. In the distribution of water the commissioner is governed by the decrees of the court defining rights, being required to close the gates of all canals whose rights have not been defined, at any time when there is not water enough for all. In order that the commissioner may know how much water he has with which to supply these decreed rights, the State engineer is required to make gaugings of streams, while ditch owners are required to put in measuring devices in order that the commissioner may know how much water he turns into each ditch. This outline makes it look as if distributing water was a comparatively simple matter, but in practice it is not so.

Many of the decrees are indefinite, making it necessary for the commissioners to interpret them. Most of them have awarded to some of the ditches more water than has ever been diverted by them, while in theory the owners of a ditch are entitled to no more water than they have put to beneficial use. Under these circumstances there is always a tendency for the holders of decreed rights to more water than they have ever used to enlarge their demand on the stream by enlarging or extending their ditches or by selling the surplus to some one else. In such a case the usual thing is for the canal owner to attempt to take the increased quantity of water claimed, when the commissioner must decide whether or not he will allow it. The commissioners have usually been inclined to enforce the theory of beneficial use and refuse to allow the increased use, even if the volume decreed was in excess of the volume used. Appeals are then made to the courts, which have a tendency to uphold the decrees, regardless of beneficial use. But in any case when such a demand comes the commissioner must first decide what he will do. Since 1899, before a transfer can be made the party wishing to transfer any right to another ditch must apply to the court for permission to do so, but parties still try to secure transfers through the commissioner. The law regarding transfers, just referred to, relates to permanent transfers only, but ditch owners may still "loan" or exchange water for short periods to save crops. There is a tendency in some sections to "loan" water which is not needed by the loaner, and to which he therefore has no right; and here, again, the commissioner must decide whether the proposed loan comes within the terms of the law.

Further complicating the matter of determining how the water supply shall be divided, the commissioner is required to see that no one taking water is allowing it "to go to waste or to be wastefully or extravagantly or wrongfully used * * * or put to any other use than that to which it is entitled to be used in the order of priority," and to shut off the supply to the extent that the water is being wasted or wrongfully used.

Any one dissatisfied with any action of the commissioner may appeal to the division engineer, and from him to the State engineer, but the usual practice has been to disregard the orders of the commissioner and then apply to the court for an injunction to restrain him from enforcing them.

The physical difficulties are equally great. Not all the streams have been measured enough times to make it possible to make rating tables which would enable the commissioner to find out each day how much water there is to divide. But the streams which have been measured vary constantly in discharge, making necessary frequent changing of the head gates of the ditches. Very few canals had accurate measuring devices, and the commissioner was authorized to put them in if the owners refused to do so and collect the cost from the owners. There was no penalty for not putting them in, and the commissioner was forced to bring suit to collect in case the owner of the ditch refused to pay. The result has been that a great many canals were without measuring devices.

In 1891 the water officials were empowered to shut off the water from any ditch in which proper head gates and measuring devices were not placed after ten days' notice. This has been quite effective, and measuring devices are now quite generally in the canals. The State engineer is required to rate the measuring flumes if they are put in, but has never had funds with which to do this. The practice has been for the engineer or a deputy to rate ditches whenever the owners would pay the expenses, but not otherwise. At present the fees paid to the State engineer for examining and approving ditch and reservoir filings and furnishing copies of the records of his office go to make up a gauging fund to be used for stream and canal gauging, but this is still too small to cover the work which should be done.

A single water district may cover 50 miles of the course of a stream and the ditches among which the water is to be divided are scattered along this distance. In this distance there are losses and gains in the flow, due to seepage from the bed of the stream and evaporation on the one hand and return seepage on the other hand. This makes it necessary for the commissioner to have an intimate knowledge of his stream, in addition to a record of the supply entering his district. The water-right holder is entitled to have a certain quantity of water at his head gate, not at the head of the stream. If the ditch is at the lower end of the district it may be necessary to let twice as much as he is entitled to go by later ditches above in order to supply him, or return seepage may supply the whole volume and render it unnecessary to turn any water down from above. The commissioner must learn by experience the behavior of his stream in order to divide its water properly. In the more highly developed districts there are measuring stations in the streams supplying the water, where daily or more frequent readings are made, and most of the ditches have measuring devices. The irrigation practice has become sufficiently settled to enable the commissioner to know how much he must turn down the stream to give each ditch its proper share of the water, and the demand for water is so great that there is little danger of wasteful use. The commissioner of such a district receives each morning by telephone a statement of the stage of the river, then goes over the stream, regulating the head gates of the ditches as may be necessary to make a proper division or telephones the ditch managers, telling them how much water to take, going over the district often enough to assure himself that his orders are being carried out.

Changing a head gate which has been set by a water commissioner is punishable with a fine not exceeding $300 or sixty days' imprisonment or both such fine and imprisonment; and the fact that the water is being used under a ditch from which it was shut out by the commissioner is prima facie evidence against the owners of the ditch for changing the head gates. The commissioners and their deputies are given the power to make arrests. Very little is done under this, however. The commissioners find that in many cases the district attorneys will not prosecute, or if they do they make little effort to convict. Juries will seldom convict for this offense. The early reports of the commissioners, published in the reports of the State engineer, are largely made up of statements of their troubles with parties who refused to obey their orders and threatened bodily harm to them in case they attempted to perform their duties. However, the sentiment against the unlawful taking of water and in favor of the punishment of those who do so seems to be growing.

The commissioners are charged also with the duty of collecting and reporting statistics regarding irrigation in their districts. They are to report the carrying capacity of each ditch and the quantity of water carried by it each day of the season, the area under each ditch and the number of acres watered, the kinds and acreages of crops under each ditch, and the amount of water stored in each reservoir. Blanks for keeping these records are supplied by the State engineer. These include blanks for a daily record of the water carried by each canal, which are to be turned in monthly and which contain columns headed: (1) Day of the month; (2) Day of the week; (3) Hour, a. m.; (4) Gauge height; (5) Quantity; (6) Hour, p. m.; (7) Height; (8) Quantity; (9) Average for day; and (10) Remarks. The last column is to contain notes of the times when gates are changed, the changes made, and what crops are being watered. There are also weekly reports to the division engineer, showing the quantity of water received by the district from different sources, the quantity of water used and the quantity flowing out of the district, the crops receiving water, the time during which water will be required, the quantity necessary to supply all needs, the date of the latest rights which are being supplied, the condition of the weather, and crop conditions.

In addition to this there is a "Water commissioner's field book," in which he keeps the record for the whole season. This contains blanks for both reservoirs and ditches. The ditch blanks contain for each ditch columns for the dates and quantities of water carried, and a summary showing the first day water was used, the last day water was used, the number of days water was carried, the average daily amount carried, the length of laterals, the number of acres that can be irrigated, and the acreages of the following crops irrigated and matured: Alfalfa, natural grass, cereals, orchard, market garden, potatoes, sugar beets, and other crops. Statements of costs of repairs, maintenance, and improvements are also included. The reservoir blanks contain columns for the dates when water was delivered, the quantity delivered, and the name of the ditch to which it was delivered, with a summary showing the amount stored prior to May 1 and the amount stored during the whole season.

The commissioners are instructed to keep two of these books, one of which is carried in the field, so that notes may be kept as the observations are made. The other is to be filled out at the end of the season and sent to the State engineer to be kept as a part of the records of his office.

These records have never been kept up by the commissioners, the reason usually assigned being that the county commissioners, who must allow the bills of the water commissioners, have refused to pay for the time necessary for the collection of the data required. The commissioners have been repeatedly urged to collect the information while about their other duties, but have not generally done so. They complain also that farmers and ditch owners will not give them the information, seeming to think that it may in some way be used to their disadvantage.

Charges against a commissioner must be made in writing to the division engineer, who is required to hold a fair and impartial trial, after five days' notice to the commissioner. If the commissioner is found guilty, the division engineer is to appoint a deputy to do the work of the commissioner. Within thirty days the engineer must file with the governor his findings, and if he recommends dismissal the governor is to appoint a new commissioner recommended by the county commissioners. The complainant must put up a bond to reimburse the commissioner in case the charges are not sustained. This is a recent law, and no cases have arisen under it.

The commissioners have been sued in the courts for damages and have always claimed that the State should defend them, but the attorney-general has refused to do this. One commissioner gives an instance where suit was brought against him, but later dismissed on motion of the complainant after the commissioner had gone to considerable expense to prepare a defense. It would seem that the State should defend the commissioner in such cases and reimburse any necessary expense.

The pay of water commissioner is $5 per day for the time actually put in. He is not to begin work in any season until called upon by some water-right holder who is not getting the water he deems himself entitled to or until ordered out by the division engineer, and is not to continue working longer than the necessity therefor exists. In the more highly developed districts along the South Platte and Arkansas rivers the commissioners put in full time, as the winter flow of the streams is used either for storage or for winter irrigation. In some other districts the commissioners work but a few days and in wet seasons not at all. The expense of distribution in 1904 in district No. 2, which includes the South Platte from Denver to the mouth of the Cache la Poudre, was for pay of commissioner, $1,800; pay of two deputies, $1,350—a total of $3,150. The acreage irrigated is estimated at 77,470 acres, making the expense about 4 cents per acre. While the division engineer is paid by the State, his salary and expenses should be charged to distribution of water. His salary is $1,500 per annum, and his expenses are limited by law to $500 per annum. There are approximately 900,000 acres in division No. 1, in which district No. 2 is located, making the cost per acre but 0.2 cent, and the total expense but 4.2 cents per acre.

The water commissioners and their deputies are paid by the counties into which the districts extend, the expenses for any district being divided equally among the counties included, regardless of the acreage irrigated in any county or the amount of work done. There is some objection to this by the counties where there is little irrigation which are in districts with other counties having large irrigated areas, and there seems to be just ground for this complaint. The law provides that the expense be paid "pro rata" by the counties, which would give some ground for claiming that the original intention was that the expense should be divided some other way than equally.

DIVISION ENGINEERS.

The office of division superintendent was created in 1887, and in 1903 it was abolished by the creation of the office of division engineer, the duties being practically the same. When the administrative system was adopted in 1879, the State was divided into districts, and provision was made for adjudicating rights in these districts independently, and commissioners were appointed to distribute water within these districts. While the whole system of water rights in Colorado is based on priority, this administrative system made no provision for recognizing priorities except within districts, although there were on some streams several districts. The creation of the office of division superintendent was a recognition of the fact that priorities should be recognized between all appropriators from the same source of supply, as well as between those within a single district. It was made the duty of the clerks of the district courts to send to the superintendents copies of all decrees regarding water rights, and from these each superintendent made a table of rights for each district within his division and a general table for his whole division. As often as required the water commissioners report to the superintendent "what ditches, canals, or reservoirs are at that time without their proper supply." "If it shall appear that in any district in that division any ditch, canal, or reservoir is receiving water whose priority postdates that of the ditch, canal, or reservoir (not receiving water) in another district as ascertained from his register, he shall at once order such postdated ditch, canal, or reservoir shut down and the water given to the elder ditch, canal, or reservoir." These orders are issued to the water commissioners, who have no discretion in the matter but to obey them. However, there is reported one case where a commissioner refused to obey such an order, and the superintendent reported to the State engineer that it would take the whole State militia to enforce his order, and therefore he thought best not to undertake its enforcement.

The division engineers have general supervision of the water commissioners in their districts, may order them on duty before they are called out by the water users, and may perform the duties of the commissioners if occasion requires. They collect data concerning reservoirs, reservoir sites, and flow of streams and perform such other duties as are assigned by the State engineer.

Complaints against the actions of the water commissioners are made to the division engineers and complaints against his actions to the State engineer. Appeals from division engineers' rulings may likewise be taken to the State engineer. The procedure for trial of charges against an engineer is the same as for trial of a commissioner, except that trial is held by the State engineer instead of the division engineer.

The division engineers and the State engineer hold a meeting in November of each year, when the reports of the division engineers are presented, and a general discussion of irrigation matters in the State is held.

Division engineers are appointed from the divisions in which they are to serve, from list of eligibles secured by examinations given by the State engineer. The examinations include questions as to measurements of streams, laws and customs relating to irrigation and water rights in Colorado, and the experience of the applicant. The appointments are made by the governor for terms of two years. The salary is $125 per month for the time actually put in and expenses necessarily incurred not to exceed $500 per annum for each engineer. The engineers usually put in full time, making the salary $1,500 per annum. There are five division engineers, making the total possible expense to the State for their salaries and expenses $10,000 per year.

THE STATE ENGINEER.

The State engineer is the nominal head of the administrative system of the State, but, in fact, he has less to do with distributing water than either the division engineers or the water commissioners. The commissioners actually distribute the water and the division engineers make rules and issue orders to the commissioners regarding the distribution, but the State engineer has no jurisdiction except as matters come up to him on appeal from the rulings of the division engineers or for review after the division engineers have passed on them.

All measuring devices are under the control of the engineer at all times, and he has had made standard designs for flumes. These are not rated, however, except upon application of the owners and at their expense. Efforts to reduce this expense are made by endeavoring to get all parties in a section to put flumes in at the same time, so that the expenses of the man making the measurements may be divided among a number of parties. A small charge is made for rating ditches, the fees going into a rating fund which is used in gauging streams.

The engineer has supervision of all reservoirs. Plans for all dams over 10 feet high must be approved by the engineer before construction begins, and he is to act as consulting engineer and require material and work to be satisfactory to him, the owner to pay expenses and $5 per day. He is to determine annually how much each reservoir in the State may store, examine dams to determine their safety whenever complaint is made by anyone living below them, and determine how much shall be deducted for losses of water by seepage and evaporation when stored water is discharged into the natural streams to be diverted below. With the exception of the filing and approval of plans and the examination of dams complained of, the law regarding reservoirs is not generally enforced because of lack of funds. There are hundreds of reservoirs in Colorado, and an annual inspection to determine how much can be safely stored would require a large outlay. The determination of the amounts to be deducted from stored water turned into streams for losses in transit is probably the most urgent of these duties which have been neglected for lack of funds, as this is a matter which produces constant friction between the owners of reservoirs and others taking water from the streams used as carriers of stored water. It would seem that the expense of making measurements for this purpose might very properly be made a charge against the parties owning the reservoir.

The engineer is required to make estimates of the amount of snowfall in the mountains during the winter as a basis for estimating the water supply for the following summer. This is done by correspondence with parties living in the mountains and by sending a deputy into the mountains whenever practicable. In addition to his duties connected with irrigation, the engineer has charge of all internal improvements, such as the building of State roads and bridges.

RECORDS OF THE STATE ENGINEER'S OFFICE.

In the engineer's office all ditch and reservoir filings are numbered consecutively and filed by the water district in which the site of the proposed works is located. These are then card indexed under three headings—the name of the ditch or reservoir, the name of the stream, and the name of the claimant.

Copies of all court decrees are filed in the engineer's office and are card indexed under the name of the ditch or reservoir.

All maps filed under the present law are of uniform size, 24 by 36 inches, and are filed in books of that size and bound.

The following fees are collected by the Colorado engineer:

For examination, filing, and certification to the duplicate of each map and statement of claim, and of each judicial decree ordering the transfer of a water right, $1; each certificate other than that made in the case of an original filing, $1; for examination and filing of each set of plans and specifications for reservoir, dam, or other structure for utilizing or storing water, $1 for each $5,000 of estimated cost; copies of plats, $1 per hour for time spent in making; copies of records, 10 cents per folio.

All filing fees from April 8 to September 15, 1905, amounted to $520.

WYOMING.

The office of Territorial engineer was created in Wyoming in 1886. Prior to that there was provision for water commissioners who were to distribute water, but no other provision for any public control of water. The Territorial engineer was given general supervision of the diversion and division of water and supervision of the work of the water commissioners. He was also to make measurements and calculations of stream flow and collect facts as to systems of reservoirs. The clerks of courts were instructed to send copies of all decrees to the engineer, who prepared from them instructions to the water commissioners.

The present system was created when Wyoming was admitted as a State, in 1890, the outlines being embodied in the constitution and the details supplied by the first legislature. The system as adopted at that time and still in existence, with only minor changes, contained two radical departures from existing practice in this country. These were the adjudication of rights by an administrative body, and the acquirement of rights through application to a public official, who had power to refuse it under certain circumstances rather than by taking the water and posting and filing a claim as notice to others of the existence of the right. These provisions were founded on a principle new to American irrigation law. The State was declared to be the owner of the water and rights to its use were to be acquired by grant or license from the State, while under the old system the water was considered as belonging to the public, and the State exercised only such supervision as was necessary to preserve the peace. This new interpretation has been denied by the supreme court of the State, although it has upheld the laws as a proper exercise of the police power of the State (Farm Investment Company *v.* Carpenter, 61 Pac., 258; Willey *v.* Decker, 73 Pac., 210), but the principle in mind when the laws were enacted was undoubtedly that the State was proprietor of the water and granted rights to its use.

The new code adopted on the admission of the State provided for the adjudication of all existing rights, the acquirement of rights in the future, and the distribution of water to those entitled to its use.

DEFINING TERRITORIAL RIGHTS.

The defining of rights acquired prior to the creation of the new system was placed in the hands of the board of control, which was composed of the State engineer as president and the superintendents of the four water divisions into which the State was divided. The State engineer makes measurements of the stream, the rights to which are to be adjudicated; determines the carrying capacities of the canals; makes examination and approximate measurement of the lands irrigated or susceptible of irrigation from the ditches, and makes a map showing the course of the stream, the location of each ditch or canal, and the legal subdivisions of land which have been irrigated or are susceptible of irrigation from ditches already constructed. The superintendent of the division in which the stream is located takes testimony as to dates of original construction and subsequent enlargements, dimensions of ditches, and areas irrigated at various dates.

Notice of the adjudication consists in the publication by the board in a newspaper in general circulation in the county when the adjudication is to take place, of a notice stating when the surveys will begin, and when and where the taking of testimony will begin. The superintendent also notifies each party having a claim on record, by registered mail, of the time for both making surveys and taking testimony, and incloses a blank form for statement of claim. Each claimant is required to certify to his statement, under oath, and the superintendent administers the oath without a charge. When the testimony is all in it is opened to inspection by all interested parties, at a time and place specified by the superintendent in a notice published for one week in a newspaper published in the county. At this time contests may be filed by interested parties, and heard by the superintendent. The testimony is transmitted to the board of control, and at its next regular meeting an order defining the rights is made. Appeal from this decision may be taken to the district court. It was provided that cases pending in the courts when this law took effect might be turned over to the board, and this was done in a few cases.

The board organized in April, 1891. At that time the courts had defined the rights on only six streams, settling less than 200 claims, while there were on record and awaiting adjudication more than 3,000 claims. The demand for adjudication was so great that in some cases testimony was taken before the surveys were completed, but this did not prove satisfactory, as the maps make possible the informal correction of many errors in description while taking testimony. For the first few years the making of these surveys was the principal work of the engineer's office. The superintendent takes this map with him when taking testimony, and is in this way able to assist claimants in making out their statements correctly. The map is submitted to claimants and acknowledgment of its correctness secured from them, making it a part of their testimony. Even with this precaution many mistakes were made in describing lands, and these mistakes often were carried through into the final certificates, necessitating the correction of these when the mistakes came to light later. To avoid this, it has been found necessary to go further and locate each tract under the ditches surveyed and mapped. In 1904 the system of making surveys was changed somewhat. A plane table of special design was adopted and the superintendent assists in making the surveys. Each irrigated tract is shown on the map, and the superintendent takes the testimony as the survey progresses. In this way there is little opportunity for mistake in land descriptions, since misstatements will be caught at once and corrected before the survey proceeds. There has been another change in practice in the interests of accuracy. Originally the superintendent received testimony at stated places, but the new system takes him among the people, reducing the chance of errors.

Each claimant is now required to pay to the superintendent at the time of submitting his testimony $1.75—the fees to the State engineer for issuing a certificate and to the county clerk for recording it. Before this law was passed many owners did not call for their certificates, avoiding the payment of the fees and rendering the county records incomplete. The payment of the fees in advance corrects this practice.

After completing the taking of testimony the superintendent gives published and written notice of the time and place where it will be open to inspection.

When the testimony is opened to inspection any interested party may contest any claims made. Most of the parties inspect the statements of others, and there is considerable informal correcting and getting together on points of difference without regular contests. The law originally provided that the contestant might fix the time and place for the hearing on his contest, but this did not work well. Parties wishing to block the adjudication would file contests and then fail to set a date for hearing them, thus tying up the whole proceeding. Now the superintendent sets the time. He serves upon each interested party a written notice of this hearing, either by mail or in person, and secures from them a waiver of any other service.

After hearing all contests the superintendent transmits to the board of control all statements of claim and all testimony taken in hearing contests. Before the meeting of the board at which this is passed upon the superintendent tabulates the results, and if there have been no contests the board usually instructs its secretary to issue certificates in accordance with the tabulation. If there are contests, the board goes more into the testimony before rendering its decision.

Any one dissatisfied with an order of the board may appeal to the courts or may, within one year, apply for a rehearing before the board. The large number of errors in land descriptions has been mentioned. Originally there was no provision for rehearing, and there was no method of correcting manifest errors after they had once been passed by the board of control. The provision for rehearing was largely for the purpose of correcting these errors. The board now has express authority to "permit, upon good cause shown, the correction of the testimony of any party or witness if it shall appear that a mistake has occurred therein." (Rev. Stat. 1899, sec. 884.) There has been a number of rehearings, especially on Green River and tributaries, in the adjudication of which many mistakes were made. There has also been a number of appeals, yet very few considering the large number of rights defined. Speaking of appeals taken in 1892, when five appeals were taken from 327 certificates issued, the State engineer said:

> These appeals were occasioned, in almost every instance, by insufficient testimony given by the appropriators themselves. * * * Most of these are really not appealing from the decrees as rendered by the board, but for the purpose of getting the matter before the courts so that additional testimony could be taken in relation to their claims, which testimony they had neglected to present before the superintendent. (First Rpt. State Engin., p. 81.)

Two of the recent decrees—the Laramie River and Blacks Fork decrees—have been appealed from on the same question. In both these cases the board held that the certificates should be issued to individual farmers under certain canals rather than to the companies owning the canals. The canal companies appealed, and the appeals are still in the courts. The usual practice under company ditches is to have the individual farmers submit proof and receive the certificates, but they must show as a part of their proof permanent agreements to take water from the companies building the ditches.

While an appeal is pending the order of the board is enforced unless the appellant files a stay bond in a sum fixed by the court, conditioned that he will pay all damages that may accrue to the appellee or appellees by reason of the order not being enforced.

Certificates are issued as soon as practicable after the issuing of an order and are by the secretary of the board transmitted, with the filing fees, to the county clerks of the counties in which the appropriations were made and by them filed.

A separate certificate is given for each enlargement.

The total number of certificates of appropriation issued from the organization of the office to November 30, 1904, about twelve years, and the acreage covered by these certificates, are shown in the table following. This includes certificates issued after construction under permit (see p. 30), as well as those resulting from adjudications. The reports of the engineer from which these figures are taken do not separate these.

Number of certificates of appropriation issued by board of control.

Year.	Number.	Acres.	Year.	Number.	Acres.
1891-92	993	203,658.00	1899-1900	379	65,579.82
1893-94	548	55,442.36	1901-2	632	81,685.60
1895-96	1,010	113,270.41	1903-4	1,098	198,901.98
1897-98	947	108,986.71	Total	5,607	827,524.88

From the time the law was enacted there were persons who for various reasons refused to submit testimony to the superintendents, and their rights were therefore not included in the orders of the board. The State engineer in his first report recommended that some provision be made for forcing such parties to come into the adjudications in order that they might be complete, but nothing was done regarding this until 1901. In 1900 such a case came before the State supreme court,[a] where it was held that under the law as it stood a party refusing to submit his claims to the board of control did not thereby forfeit his right, since the law attached no penalty to such refusal or failure, but the court intimated that it would be competent for the legislature to make the penalty the forfeiture of all rights to water. In 1901 such a law was passed (Laws 1901, p. 70). It provided also that those who prior to that time had failed to join in adjudications must within one year apply to the board for a hearing or forfeit their rights. This year extended from February 16, 1901, to February 16, 1902, and during that time thirty-six petitions were received. Two were received after the expiration of the year.

Most of the smaller streams of the State have been adjudicated, and some of the larger ones, but the large streams generally have not yet been taken up. There is as yet unappropriated water in these streams, and the pressure for a settlement of rights has not been so great as on the smaller streams. In some cases rights on the tributaries have been defined, while those on the main stream have not, although these rights may be interdependent. Under such circumstances, when all the rights have been adjudicated, the board is to give notice of times and places for placing on inspection all the evidence and its findings, when any finding may be contested by anyone not a party to the original adjudication in which it was made. After this inspection and hearing of contests the board is to make one decree covering the stream and its tributaries. No such case has arisen yet, but will when the North Platte River is adjudicated, as the rights on its tributaries have been defined in separate proceedings.

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[a] Farm Investment Co. *v.* Carpenter, 61 Pac., 258.

The expense of an adjudication to a claimant is very small, outside of the $1.75 fees, which must be paid to the superintendent when testimony is submitted. The cost of publishing notices is paid by the county in which the adjudication takes place, and the State pays for the surveys. The only expense to the claimant is the time it takes to make out his proof with the help of the superintendent, examine the proofs submitted by others, and present testimony in case of contest. The last might of course be expensive.

ACQUIREMENT OF RIGHTS.

As was stated, the Wyoming system of acquiring rights was at the time of its adoption entirely new to American irrigation law, although its general features are common to European countries. It is based on the theory that the State is the owner of the water and grants and controls rights to its use, instead of supervising the acquirement and regulating the enjoyment of rights to a public property. The supreme court of the State has, however, held that the latter is the correct theory (see p. 19). This distinction has so far made no difference, but questions may arise in the future when it will.

The person wishing to acquire the right to use water must before beginning construction make application to the State engineer and receive a permit from him. The engineer has authority to refuse an application when there is no unappropriated water in the source of supply or when its granting would be contrary to public policy, and since 1895 the engineer is empowered to require the applicant to show his financial ability to carry out the proposed work. The time within which the appropriation must be completed is fixed by the engineer, and on or before the expiration of this time the applicant must submit proof of having carried out the provisions of the permit. On receiving satisfactory proof that this has been done, the board of control issues a certificate of appropriation (see p. 22). If the appropriation is completed in accordance with the permit, the right dates back to the time of making the application.

The effect of this change from the old system of unrestricted filing of claims is stated in the first report of the State engineer as follows:

> The superiority of this method of procedure over the former method of recording claims has been marked. The preliminary examination prevents the records being cumbered by incomplete or imperfect statements. Although a blank on which to make this application is furnished by the office, nearly one-half of those received have to be returned for corrections. The rejection of excessive claims or their diminution, by the engineer, has been a most effective educator and has forestalled numerous neighborhood controversies which were certain to arise under the unrestricted diversion heretofore permitted. So long as there was no examination of the statement filed, appropriators of a small volume of water would record claims to the entire stream, under the belief that they secured the right to the

full amount of their claim; and, believing this, there was a natural disposition to prevent, if possible, the use of any part of this by others. Under the present law the appropriator is restricted in the permit to the amount actually used within the time designated, and in this way all claim to the ownership of water for speculative purposes is averted.

The present law is destined to be a great aid in the construction of extensive canals. Such canals require a considerable period for their construction and an additional time after completion in which to apply the water to the intended use. Under the old law there was no security that smaller works would not divert and utilize a considerable portion of the water supply before the more extensive project could be brought into service. This is not possible under the present law. An approved permit is a guaranty from the State of the following facts:

(*a*) That the engineer believes there is an adequate water supply.

(*b*) That if the conditions of the approval are complied with no question can arise as to the date or amount of the appropriation.

(*c*) That within the period fixed for the completion of the appropriation other appropriators will not be permitted to divert and absorb the water supply and that a limit will be placed on subsequent appropriations, thus obviating future conflicts with the owners of ditches for which there is no water.

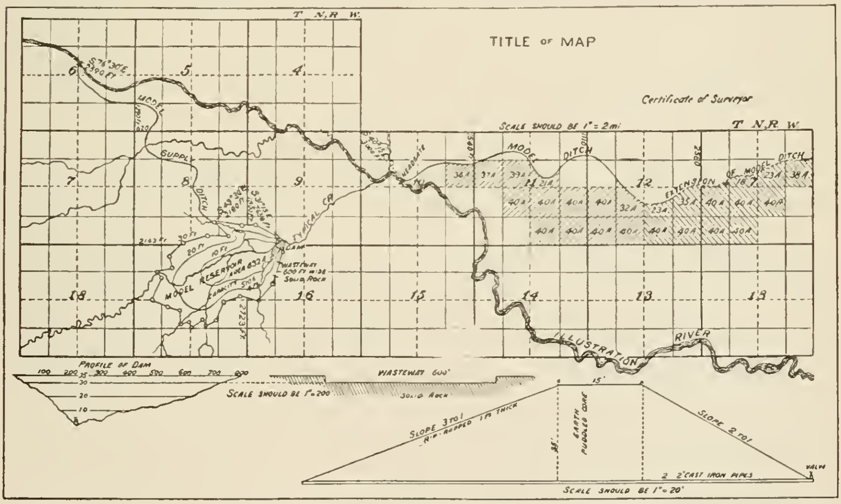
T N, R W.
TITLE OF MAP
Certificate of Surveyor
Scale should be 1" = 2 mi
T N, R W
6
5
4
7
8
9
18
16
15
14
13
12
11
S76°30'E 2390 Ft
MODEL
SUPPLY
DITCH
MODEL DITCH
EXTENSION OF MODEL DITCH
HEADGATE
TYPICAL CR
DAM
2163 Ft
30 Ft
20 Ft
10 Ft
MODEL RESERVOIR AREA 632 A
CAPACITY 5106 A.Ft
WASTEWAY 600 FT WIDE SOLID ROCK
2723 Ft
2380
36 A
37 A
39 A
21 A
40 A
32 A
23 A
35 A
18 A
38 A
30 A
ILLUSTRATION RIVER
PROFILE OF DAM
100
200
300
400
500
600
700
800
35
30
20
10
WASTEWAY 600'
SCALE SHOULD BE 1" = 200'
SOLID ROCK
15'
35'
SLOPE 3 TO 1 RIP-RAPPED 1 FT THICK
EARTH PUDDLED CORE
SLOPE 2 TO 1
2 2" CAST IRON PIPES
VALVE
SCALE SHOULD BE 1" = 20'

FIG. 1.—Sample map for applicants for water rights in Wyoming.

The first step in acquiring a right is to apply to the State engineer for the necessary blank. With the blank is sent a sheet of instructions, on the back of which is a sample map, reproduced in figure 1. The instructions are in part as follows:

APPLICATIONS.

Applications must be made upon the blank form approved by the State engineer, and all blank spaces are to be filled. Applications to enlarge existing ditches, or to increase the acreage watered therefrom, must be made on an enlargement blank, and the entire irrigation system must be shown complete from stream to end of ditch. In giving dimensions, remember the following:

"Width on top" is the width at surface water line. "Depth" is the depth of water which the ditch or canal is to carry.

The area to be irrigated must be given, where not measured an estimate must be made, and where only part of a subdivision is to be watered, the estimate must give the acreage in each 40 acres of these fractional subdivisions, with the number of acres marked in each.

The law requires applications to be made and approved by the State engineer before work begins. No application which states that work has begun or has been completed will be approved.

MAPS.

Each application must be accompanied by two maps, one of which must be on tracing linen.

These maps must be neatly and accurately drawn with India ink to a scale of 2 inches to the mile, and on sheets not less than 9 by 12 inches.

They must show the location of the head gate by courses and distances from some government corner. They must show the actual location of the ditch or canal, and where government survey lines are crossed, the distance to the nearest corner must be given. (Where corners can not be found, give the location of line by courses and distances.)

The map must show the course of and name of stream from which water is taken; the location and area of land to be irrigated, or place where water is to be used for other purposes. (This may be done by marking the boundaries or by coloring the areas.)

Whenever the canal line crosses streams or other ditches the location of such crossings must be shown, and such intersecting streams and ditches must be marked by ink of a different color.

Maps must contain the name of the ditch, canal, or reservoir, and the post-office of the surveyor, with date of survey.

RESERVOIRS AND DAMS.

Applications for reservoirs and dams must be accompanied by a map in duplicate on tracing linen, showing the dimensions and location of the reservoir. The dam must be tied to some government corner by courses and distances.

Plans of dams, cribs, or embankments must be drawn on longitudinal scale of not less than 1 inch to 200 feet and for cross sections of not less than 1 inch to 20 feet. Timber, brush, and stone, where used, shall be shown in detailed plans, the scale of which shall be 1 inch to 4 feet. The plans for outlet and waste ways for reservoirs shall be drawn on a scale of 1 inch to 4 feet, and are required for all dams over 5 feet high in a running stream or for any other dam over 10 feet high.

The maps of reservoirs shall show the total area to be submerged and enough levels to permit of computing their capacity.

For earth dams the slope must not be less than 3 to 1 for the front or water side, and 2 to 1 for the back.

NOTE.—Lands may be shown by tinting with a colored pencil on the dull side of the tracing linen and this rubbed to an even tint by means of a medium hard rubber eraser. Where an enlargement application is made, the lands under existing rights through the same ditch should be shown in different colors. Colors which will not blueprint well should not be used. The preferred colors are: Green, orange, red, and yellow. Lettering on a map should be sparing and superfluous matter should not be placed thereon. Indelible pencil or a typewriter should not be used on tracing linen, since the oil in the cloth will cause these colors to spread and in time it becomes almost obliterated. The affidavit of the surveyor should be neatly lettered on the map. In preparing an application the 40-acre subdivision in which the head gate is situated should be stated and the bearing and distance to the nearest government corner should be given. In case of an enlargement, if the applicant is the owner of the ditch to be enlarged, he should so state, if not, the written consent of the owners must accompany the application. The following form for consent to enlarge may be used.

——— ———, 190—.

I (or we) ———, the sole owner of the ——— ditch taking water from ———, under permit No. ——, do hereby give my (or our) free and voluntary consent to the enlargement or extension of and to the use of water through the said ditch by ———, according to the terms of this enlarged permit.

——— ———,

——— ———.

The application must show the name and post-office address of the applicant, use to which the water is to be applied, the name of the ditch or canal, the source of water, location of head gate, the length and dimensions of the ditch, the character of the material to be moved, the amount of tunneling and fluming, estimated cost of the works, description of the lands to be irrigated, time when work is to begin, time when the works are to be completed, and the time when the water is to be applied to a beneficial use.

An application is given a temporary number and acknowledged as soon as it is received. When it has been approved it becomes a permit and is returned to the applicant with a notice calling his attention to the law requiring the submitting of proof of completion of works, to which is attached a stub to be used for this purpose.

Unless proof of completion has been previously received, a short time before the expiration of the time allowed for the completion of works under a permit notice is sent calling the attention of the appropriator to the fact that the time is about to expire and warning him that unless proof is submitted within thirty days his permit may be canceled.

The proof of appropriation must show the name and address of the appropriator, the permit number, purpose for which the water is taken, the dates of beginning and completing construction and of applying the water to a beneficial use, the dimensions of the ditch, description of the land irrigated, crops grown, the time during each year when the water is used, the amount of the investment in the ditch, the estimated cost of preparing land for irrigation, and a statement as to whether the map filed with the permit shows correctly the completed works and the lands irrigated. This statement must be sworn to by the appropriator. The proof of appropriation is accompanied by a statement from the superintendent of the water division in which the works are located that he has examined the works and found them to be as stated in the proof, or otherwise, as the case may be; that the proof has been open for public inspection, and that he recommends that the certificate of appropriation be issued in accordance with the proof.

Applications for the enlargement of existing works are made on forms substantially the same as those used for original applications, except that they have blanks for descriptions of the works as they are and as they are to be enlarged.

Under the original law no fees were required and maps were to be filed within six months after approval of the application, instead of with the application, as is done now. In his second report the State engineer called attention to two evils resulting from these provisions. He said:

> Parties who have no well-defined idea of constructing ditches file applications for permits simply because it costs nothing * * * The tendency of recording speculative filings is only one of the evils. The more aggravating one is the carelessness with which many of the statements are prepared.

The same report shows the operation of the law at that time. Four hundred and seventy-two applications were received, to reclaim 1,275,303 acres. Plats were filed with 325 of these. Extension of time for filing plats was granted in 10 cases. Sixteen applications were rejected because of no unappropriated water in the source of supply, 26 were canceled for failure to file plats or because of notice of abandonment from applicant. Before a permit is canceled two notices are sent to the applicant, in order that he may have opportunity to show cause why it should not be done.

In response to recommendations of the engineer the legislature of 1895 provided for the payment of fees, that maps and plats of prescribed form and size be filed with the application, rather than within six months after its approval, and authorized the engineer to satisfy himself as to the financial responsibility and good faith of the applicant before approving an application. This resulted in a great improvement in the character of applications and the accuracy of the maps filed.

Another safeguard recommended by the engineer in his first report was the publication of notice of an application in order that those whose interests might be affected by its approval might have a hearing before the engineer. This has not been adopted, but it is the practice of the engineer to furnish statements of the applications received to the newspapers of the State, so that they are usually published. This provision has been adopted by several of the other States.

A question which early arose was whether a permit for the appropriation of water for a given area of land is exclusive. Logically it would seem that it should be. The right is supposedly attached to the particular tract of land described in the permit, and is limited to 1 cubic foot of water per second to 70 acres. If two permits covering the same land are issued, the engineer's office is in the position of having authorized the diversion of 2 cubic feet of water per second for a single tract of 70 acres. It is true that no one can get a certificate of appropriation until proof of actual beneficial use is made, and consequently only one right can be acquired for a given tract, but until the time for final proof there would be two parties with permits to acquire a right to which only one could finally receive title. On the other hand, the effect of making permits exclusive, under certain circumstances, works great injustice. Under the Wyoming law and practice there is no requirement that the applicant shall own the land which the proposed canal is to water; in fact, under large canals they seldom do. An exclusive permit under such circumstances makes the owner of the land entirely dependent on the holder of the permit, since he is barred from acquiring a water right for his own land except through the holder of the permit. The evils of this latter situation appealed more strongly to the Wyoming engineers than the logic of the former, and they have therefore never held that permits were exclusive. In his second report the engineer stated his position on this matter as follows:

> The State having given a permit to use water for the irrigation of certain lands, and fixing a time for its completion, no other permit should be issued covering the same land until the first shall have expired. This course has been adhered to in all cases where parties having prior claims show their intention and ability to proceed without delay with the work. (Second Rpt. St. Eng., p. 54.)

In his next report the engineer, referring again to this subject, says:

> In all these cases it has been the effort of the engineer to take such action as would secure the most effective reclamation of land and the best use of our water supply, and where this has required the issuance of a second permit, describing the same land, then such permit has been issued, but whenever the question was in doubt or where the issuance of a second permit tended to interfere with the carrying out of a project already under way, all such applications have been rejected. (Third Rpt. St. Eng., pp. 63, 64.)

The opposite interpretation has been given in Nebraska (see p. 45).

While the engineer has authority to reject an application when there is no unappropriated water in the source of supply mentioned in the application, and this has sometimes been done, it is not the usual practice. There is usually some flood water, and always the possibility of an increased supply from seepage or more economical use by the holders of prior rights, and consequently permits are frequently granted when the records of the engineer's office show little unappropriated water. The location of the proposed diversion is taken into account in such cases. If it is at the lower end of a stream where interference with prior rights is impossible the permit is granted, while if it is on the upper part of a stream where there will always be the possibility of interfering with lower prior users, the permit may be refused. Another practice recently adopted is to ask the applicant to get the written consent of the prior appropriators from the same source. When this is secured the permit is granted. In all cases where the records show little or no unappropriated water, that fact is stamped across the face of the permit. The form of this notice is as follows:

> The records of the State engineer's office show the waters of ——— to be largely appropriated. The appropriator under this permit is hereby notified of this fact and that the issuance of this permit grants the right to divert and use the surplus or waste water of the stream and confers no rights which will interfere with or impair the use of water by prior appropriators.

Since the adoption of the present system of acquiring rights a number of canals have been built without complying with the law regarding making application to the State engineer. The status of such ditches was referred to the attorney-general of the State, and in 1893 he gave it as his opinion that the board of control can not issue a certificate of appropriation to such a party except after the issuance of a permit. The party can, however, make application, receive permit, make proof of appropriation, and receive certificate, even if the works were completed before the application was made. (Second Rpt. St. Eng., p. 195.) In 1896 the engineer issued instructions to the superintendents in accordance with this ruling, stating that they should refuse to take proofs of appropriation for ditches built after the enactment of the law without compliance with its provisions. (Third Rpt. St. Eng., p. 69.) The builders of these ditches were required to make application in the regular way. The circular of instructions sent out with blanks to applicants (see p. 25) is not in accord with this ruling, where it says, "No application which states that work has begun or has been completed will be approved," and is not lived up to.

Since the organization of the engineer's office there have been approved 6,292 applications for the construction of new ditches and 1,269 applications for permits.

The procedure for making proof of appropriation is not laid down by the law, which provides for the issuance of the certificate "upon its being made to appear to the satisfaction of the board of control that any appropriation has been perfected in accordance with such application and the indorsement thereon by the State engineer." It has always been the intention to have each ditch built under permit inspected by the superintendent of the division in which it is situated before certificate is issued, but this has not always been possible, and where ditches are in remote districts certificates have sometimes been issued on the reports of water commissioners. (Third Rpt. St. Eng., p. 47.) In 1901 a law was passed authorizing this practice where permits have been issued since the streams in question were adjudicated.

The present procedure under the rules of the board of control is as follows:

> The rules of the board * * * require before the issuance of a certificate of appropriation under a permit that the respective superintendents make personal examination of all such ditches at the time of submission of proof by the appropriator and subsequently, after publication of notice in a newspaper circulating in the vicinity, fixing a time and place, they appear and open all such proofs to public inspection, when any interested appropriator has an opportunity to make any objections he might have to any such proofs. (Rpt. St. Eng., 1901-2, p. 66.)

The superintendents have never been able to keep up with this work, and there are a great many ditches which have been completed and whose owners have notified the State engineer of their readiness to submit proof of this fact, for which proof has not been taken. In the spring of 1903 there were 1,029 such ditches on record in the engineer's office, and steps were at once taken to systematize this work in order that it might be brought up to date. Previous to that time the superintendents had no list of such ditches in their divisions, and had taken proof as opportunity offered and when specially requested by the ditch owners. Under the new plan, a card index of all such ditches has been prepared, arranged by streams. On a card are placed the name of the stream, the permit number, references to the records, the name of the applicant, the name of the ditch or reservoir, the priority number, the date of appropriation, the amount of water appropriated, and the description of the lands for which the permit was granted. A set of these cards showing all such ditches in his district is furnished to each superintendent, giving him full information as to ditches awaiting proof. Now whenever he goes into the field he refers to his index, and if there are completed ditches in the section he is to visit the cards are taken along and proof is taken while he is there. This is rapidly bringing the work up to date and cutting down the expense to the lowest possible figure, as very little travel is undertaken for the especial purpose of taking proofs. To further expedite matters, the superintendent of district No. 3 has recommended that the board accept the testimony of two or more disinterested witnesses, as is done in proving up on desert-land claims. This suggestion has not been acted upon by the board of control, however.

Perhaps the most important reason for keeping up to date in taking proof of appropriation and issuing certificates is that a great many ditch owners are taking up land under the desert-land law and need the certificates in making final proof on their lands. The General Land Office originally required the certificate with final proof on land, but the State got so much behind in this matter that the Land Office amended its rules in 1899 as follows:

> Proof, if otherwise satisfactory, will be accepted upon the filing of a certified copy of their approved application, together with proof that they have completed the appropriation in the manner required by the State laws and regulations and properly reported that fact to the State engineer, and this evidence will be taken as sufficiently establishing their clear right to the use of water. (Rpt. St. Eng., 1899–1900, pp. 62–63.)

This rule was changed in 1904, and the certificates are now required by the General Land Office The average cost of acquiring a water right under the present procedure has been about $13.

DISTRIBUTION OF WATER.

The Wyoming system of distributing water is copied from the Colorado system and is in general the same (see pp. 11–16). There is, however, a more direct control over the water commissioners by the superintendents. The authority of the engineer over the division superintendents in the matter of distributing water has been questioned, and in 1901 the opinion of the attorney-general on this question was asked. He upheld the authority of the engineer.

Consistently with this, anyone deeming himself injured by any act of a water commissioner may appeal to the superintendent, from him to the State engineer, and from the engineer to the district court.

The distribution of water has always been hampered by the existence of unadjudicated rights. The water commissioner has no guide in such cases, yet the rights are unquestioned although undefined. In many cases the holders of these rights refused to recognize the authority of the commissioner and also refused to submit testimony in adjudications. However, this was remedied so far as adjudicated streams are concerned by the law of 1901, compelling such parties to submit their rights to the board of control, on penalty of forfeiture. On unadjudicated streams there is still this trouble.

Another phase of this same question was settled by an opinion of the attorney-general in 1901. That was the status of rights under permits, for which certificates had not been issued. Complaints were made by the holders of such rights that they were being interfered with by subsequent but adjudicated rights. The opinion of the attorney-general on this point was that the commissioners should deliver water in the order of the dates of permits, provided the ditches were ready to receive it, the permits being as binding on the State as certificates. (Rpt. St. Eng., 1901–2, p. 51.)

The general instructions to the water commissioners are to get the largest possible service out of the water supply, but that priorities must be enforced when demanded, even if the supplying of 1 cubic foot per second at the head of an early ditch requires the loss of 10 cubic feet per second in the sand of the channel.

Commissioners were formerly to begin work on the call of two or more persons having rights to water, but it frequently happened that one person whose rights were being interfered with could not secure the signature of a second person to his call for the services of the commissioner. The law was therefore amended in 1901, authorizing the commissioner to begin work on the call of one appropriator, if the commissioner deems it sufficiently important.

Appropriators are required to maintain head gates and measuring devices to the satisfaction of the superintendent of the division, and standard plans have been sent out by the State engineer. The original law requiring these structures provided that in case of neglect to put them in after thirty days' notice from the superintendent, that officer was to report the matter to the county commissioners, who were to put in the structures at the expense of the county and assess the cost against the land in case the appropriator refused to pay it. Under this law a party could delay action for a whole season, and county commissioners might even then refuse to act, rendering it impossible to secure the putting in of the structures. On the recommendation of the engineer this law was amended in 1901, providing that if an appropriator neglects to put in the structures within ten days after notice from the superintendent, the commissioner is to close the ditch to the passage of water, and that when the superintendent has ordered a measuring device put in for a reservoir in the channel of a stream and it has not been done the commissioner is to draw off the water. This has been found to be the only effective way to compel the putting in of head gates and measuring devices in other States as well as Wyoming.

Interference with head gates which have been set by a water commissioner has always been a misdemeanor, but until the use of water through a canal closed by a commissioner was made prima facie evidence of having opened the gates (Laws 1901, sec. 971) it was almost impossible to secure convictions unless the person was actually caught by the commissioner himself in the act of opening the gate. Those caught using water usually claimed that some person unknown to them had opened the gates. The penalty for interfering with a gate set by a commissioner is a fine not exceeding $100 or six months' imprisonment, or both fine and imprisonment. Another common way of accomplishing the same purpose as changing a gate is obstructing the stream channel below a gate only partially closed, thus increasing the flow through it. The superintendent of division No. 2 recommended in 1900 that this also be made a misdemeanor, and the law regarding changing gates as amended in 1901 seems to cover this in the clause "willfully use or conduct water into or through his ditch which has been lawfully denied him by the water commissioner or other competent authority."

The law makes it the duty of the water commissioner to so regulate and control the use of water in his district as to prevent the waste of water, but it has been the usual practice of the commissioners to pay no attention to what became of the water after it was turned into the heads of ditches, and to give to each ditch owner the entire amount of his right so long as it was called for and the stream supplied it. This led to frequent complaints from the holders of late rights who were unable to secure water while others were using it wastefully. June 26, 1902, the State engineer issued an order to the superintendents calling their attention to the law against waste and stating that "it is unquestionably the duty of the water commissioner to make whatever examination may be necessary to determine whether water is being wasted, or wastefully, extravagantly, or wrongfully used when needed by others, and to shut off the water from any ditch to whatever extent may be necessary to prevent such wasteful or wrongful use." (Rpt. St. Eng., 1901–2, p. 31.)

When reservoir owners wish to use the channel of a natural stream for conveying stored water it is their duty to notify the commissioner in charge of the stream and supply him with a list of the parties entitled to divert the water. The commissioner then distributes the water to those entitled to it, half of the expense of this distribution being charged against the county and half against the owners. The county commissioners collect this from the owners, and in case of nonpayment tax it against the reservoir.

It is not possible to get at the exact expenses of the distribution of water by public officials, but in his report for 1901–2 the State engineer gives the results of an inquiry along this line. In division No. 1 the expense for distribution in 1902 was 5 mills per acre for adjudicated rights; estimating unadjudicated rights as covering an equal area, the expense for the whole was 3 mills per acre. In division No. 2 the expense for adjudicated rights was 5.8 mills per acre, but in division No. 3 it was 34 mills per acre. This large expense was caused by the employment of a large number of deputies on Grey Bull River, the expense on this stream being 6 cents per acre. No figures are given for division No. 4.

MISCELLANEOUS DUTIES OF THE STATE ENGINEER.

Duplicate plans of all dams above 5 feet in height in running streams and all dams intended to retain water above 10 feet in height must be submitted to the engineer, and his approval must be secured before construction begins. The engineer has authority to inspect during construction any such dam, or any ditch, canal, or other work carrying over 50 cubic feet per second, and may order any changes he deems necessary for the security of the work or the safety of those residing below. The engineer is also to examine any irrigation works complained of by anyone living in the neighborhood of the works, but may require the complainant to put up the cost of the inspection. If the complaint proves to have been justified, this cost may be assessed against the owners of the works, and the deposit refunded to the complainant. There have been a large number of plans of dams filed. Until 1895 there was no provision for inspection, and it was found that plans were made to conform to the requirements of the engineer, and after approval were abandoned. For small dams the engineer thought best to let matters run along as they were, since inspection would be too expensive. The law providing for inspection was passed in 1895. No cases have arisen under the provision for complaints as to the safety of works.

Since 1903 those wishing to construct reservoirs are required to apply to the engineer for permits in the same manner as for ditches, except that the lands to be watered need not be described, as it is the expectation that the water will be sold. The engineer is authorized to appoint an assistant to supervise the construction of reservoirs whenever he deems it necessary. The orders of this assistant are to be obeyed by those in charge of the work, except that they may appeal to the State engineer, whose decision is final. The expense of this supervision is to be paid by the applicant. The engineer may cancel the permit if his orders are not complied with. The practice under this act has been for the builders of a reservoir to employ an engineer who is satisfactory to the State engineer, and only the most general supervision is exercised by the latter.

All proposals to reclaim land under the Carey Act are submitted to the State engineer, who examines them and determines—

> Whether or not the proposed works are feasible; whether the proposed diversion of the public waters of the State will prove beneficial to the public interest; whether there is sufficient unappropriated water in the source of supply, and whether or not a permit to divert and appropriate water through the proposed works has been approved by him; whether the capacity of the proposed works is adequate to reclaim the land described; whether or not the proposed cost of construction is reasonable, and whether or not the maps filed in his office comply with the requirements of said office and the regulations of the Department of the Interior; also whether or not the lands proposed to be irrigated are desert in character and such as may be properly set apart under the provisions of the aforesaid act of Congress and the rules and regulations of the Department of the Interior thereunder. Whenever the State engineer shall be unable, from an examination of the maps and field notes submitted for his examination, to determine whether or not the proposed irrigation works are feasible and adequate, whether or not the proposed cost of construction is reasonable, or whether or not the proposed diversion of the public water is beneficial to public interest, and whether or not the lands proposed to be irrigated are of such a character as to come under the provisions of the aforesaid act of Congress, the board may direct the engineer to make or cause to be made by some qualified assistant such survey or examination as will enable him to report intelligently thereon to the board.

In addition the applicants must secure from the engineer a permit to appropriate water in the regular way. Under this act 556,593.39 acres have been segregated, and about 50,000 acres patented.

Parties wishing to float or drive logs in any of the streams of the State must apply to the State engineer for permission to do so, and must, if required by the engineer, give bond in a sum to be fixed by the engineer for the protection of irrigation ditches and property along the stream.

The board of control has uniformly held that water rights should be and are attached to the land in connection with which they are acquired, but in practice the board has sometimes departed from the rule. Where the original land has been ruined the old certificate has been recalled and a new one issued describing the land to which the right is transferred, bearing the date of the original certificate, and an explanation of the change made. In 1904 the supreme court of the State overruled the board of control in this matter and held that rights can be transferred if others are not injured[a] by the change. One of the chief objections to transfers has been that they destroyed the value of the record of the State engineer's office as a guide for the distribution of water. However, this objection was removed by the passage of a law in 1905 providing for notice to the engineer when a transfer is made. A transfer is to be made by deed, which is to be recorded with the county clerk of the county where the water is used and with the State engineer. The official distributing water is not required to take any notice of a transfer until the deed is recorded, and not then if in his judgment or that of the board of control it is injurious to any person not a party to the transfer, until the validity of the transfer has been established by a proper court. If the transfer is recognized a notice of this fact must be published in a newspaper having general circulation in the county where the transfer is made, at the expense of the party making the transfer. In case the transfer is not recognized, the party to whom the right is transferred may sue for injunction to restrain the State officials from interferring with his enjoyment of the right. Notice of this action must be published, and any appropriator has the right to intervene and have his rights in relation to the transfer fully determined. In case an injunction is granted which is afterwards found to have been wrongfully obtained the appropriator intervening has the same right to recover damages as if he had originally been a party to the action. The attorney-general of the State is to appear for and defend the irrigation officials whenever they are made parties to any court proceeding.

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[a] Johnston *v.* Little Horse Creek Irrig. Co., 79 Pac., 22.

The effect of this law has been that parties intending to make a transfer consult the State engineer in advance to determine whether he will recognize it if made. It insures that no transfer will be made without full notice to all interested parties, and to the State water officials, and puts on the one wishing to make the transfer the expense of advertising it and the liability for damages if he persists in making the transfer when it has been denied by the State officials.

Another class of transfers is still unprovided for. These are transfers of lands which carry with them the rights to water. There is no provision for making a record of such transfers in the State engineer's office, and consequently the records do not show correctly the ownership of rights. It is frequently desirable to send notices to water-right holders, and often these notices are not received, because the original owner has transferred his land and water right and left the State. Legislation to cover this has been recommended but never passed.

APPOINTMENT, QUALIFICATIONS, AND PAY OF OFFICIALS.

The office of State engineer is created by the constitution, Article VIII, section 5. He is appointed by the governor, confirmed by the senate, holds office for six years, and receives a salary of $2,500 per annum. No person is eligible "who has not such theoretical knowledge and such practical experience and skill as shall fit him for the position.

The superintendents of the four water divisions are appointed by the governor with the consent of the senate, serve four years, must reside within their respective divisions, and receive salaries of $1,200 per year and necessary traveling expenses, paid by the State since 1903. Before that they received $8 per day for the time actually employed. Until 1903 the superintendent of Division No. 1 was also secretary of the board of control and received a salary of $1,500 per year. As the work of the board increased it was necessary to have some one constantly in the office of the board, and the office of secretary of the board was created. The salary is $1,200 per year, paid by the State.

Water commissioners are appointed by the governor from lists of persons submitted by the superintendents of the divisions where they are to serve, and must be residents of their respective districts. The term is two years, and the pay $5 per day for each day actively employed in the duties of the office. This is paid by the counties, each county paying for the work done within its limits. Commissioners have power to appoint suitable assistants, who receive $4 per day, but may not receive pay for more than thirty-five days in any one year. The superintendents have repeatedly recommended that the provision that commissioners must be residents of their districts be repealed, because they have found difficulty in finding suitable persons who would accept the office, but this has not been done. In a number of counties commissioners have been put on salary of $75 per month by agreement between water commissioners and county commissioners. Districts are being divided to avoid the necessity for traveling long distances to do a very little work.

RECORDS OF OFFICES OF STATE ENGINEER AND BOARD OF CONTROL.

When an application for permit is received in the office of the State engineer it is filed and a receipt is sent to the applicant. The filing books are numbered, and the pages each contain spaces for the records of six applications, showing the name of the stream, the name of the ditch or reservoir, the name of the applicant, his post-office address, and the disposition made of the application. On its receipt an application is recorded in such a book and given a temporary number, which shows the book, page, and position on the page where it is recorded. It is then placed in a case with all other applications from the same division which are not yet acted on. Upon examination they are placed in another case of "Applications for approval." When approved they are filed in a third case awaiting recording. They are then recorded, given a number, and mailed to the applicant. The pages of the record books are similar to application blanks (see p. 25), and the applications are copied into these books in the order of permit numbers. Applications for original construction and those for enlargements are kept in separate books. In these record books and on the face of the recorded permits record is made of all subsequent action under the permits. Such notes as "Notice of expiration sent November 1, 1901," "Canceled," "Completed, proof submitted October 15, 1904," "Certificate issued January 1, 1905," appear on these records. Maps received with applications are kept with them until given a permit number, when they are folded and filed in cases by the permit numbers.

All records are indexed on cards by streams and by the legal subdivisions in which the works are located. The cards of the stream index have at the head the name of the stream from which water is taken and the name of the stream of which this is a tributary. On the cards are columns for permit numbers, names of applicants, names of ditches, dates of filing, location of head gates, and priorities (date). The land description cards have at the head the township, range, and division numbers and columns for the sections, permit numbers, names of streams, ditches, and applicants. In each case the permit number is sufficient reference to the other records of the office. Adjudicated territorial rights are also included in this index. All correspondence is card-indexed by the name of the correspondent, and on these cards are placed the permit numbers if the persons are appropriators of water. The records are therefore indexed by the name of the person, the name of the stream, and the location of the land reclaimed.

There are on file in the engineer's office, in addition to the maps submitted with applications, maps made by the engineer in adjudicating territorial rights and taking proof under permit. From all of these the engineer is making township plats on the scale of 2 inches to the mile, showing the ditches and the lands irrigated by each. These are made on tracing linen, and the lands irrigated by different ditches are shown in different colors. It is the intention to make these cover the entire State, and as new ditches are built they will be placed on these maps.

All fees received by the engineer are entered in a book as they are received, deposited in a bank, and turned over to the State treasurer at the beginning of each quarter.

The records of the board of control consist chiefly in the minutes of the meetings of the board, containing all orders made by the board, and the proofs of appropriation taken by the superintendents. The proceedings of the board are indexed only in an ordinary alphabetical index. The proofs of appropriation are given numbers and are filed by these. From these the superintendent makes a tabulation for submission to the board. These tabulations are made in loose leaf books having columns showing general priority number, stream priority number, name of ditch, name of stream, name of appropriator, post-office address, date of appropriation, use to which water is applied, amount appropriated in cubic feet per second, number of acres irrigated, and description of lands irrigated. If any changes are made by the board in its final adjudication, they are put on these original sheets in red ink. These are bound in books and form the records of adjudicated rights. Certificates are made out by the secretary from these tabulations. These are in books with duplicates, one copy being sent to the appropriator and the other retained in the form of a stub. The certificate has on it the book and page containing the stub.

The secretary of the board keeps also a card index showing the status of rights under permit (see p. 31) for use of the superintendents in taking proof on such rights. He also prepares tabulations of all rights for use by the water commissioner in distributing water. These are made out by streams and show the permit number, the general priority, stream priority, name of ditch, name of appropriator, amount appropriated, and number of acres.

FEES.

The State engineer is to collect the following fees, which are to be paid into the general fund of the State:

Filing and examining applications and map, $2; recording any water-right instrument not specified above, $1 for first 100 words and 15 cents for each additional folio; for issuing certificate of appropriation, $1; for making certified copy of any document recorded or filed in his office, 15 cents per folio, and $1 for each certificate attached thereto.

Prior to 1895 there were no fees. The fees received since that time are shown in the following table:

Fees received by State engineer's office.

1895	$673.90
1896	910.80
1897	1,089.55
1898	1,098.80
1899	1,465.70
1900 to November 30	1,800.50
1901–2 to November 30	4,748.05
1903–4 to November 30	5,820.79

In his report for 1903–4 the engineer calls attention to the fact that the amount of money turned into the treasury by the office was $34.64 in excess of the entire contingent fund at the disposal of the office for the same period.

When an appeal is taken from the board of control to the court, a transcript of the records of the board must be filed with the court by the appellant. The fees for making transcripts for the two years ending November 30, 1904, amounted to $813.85.

NEBRASKA.

In 1895 Nebraska adopted a system of water administration similar in outline to the Wyoming system, but differing considerably in detail. It provided for the administrative defining of existing rights, for the acquirement of rights under State supervision, and for the distribution of water by State officials.

The State board of irrigation is at the head of this system, but this differs from the Wyoming board of control in that it is composed of State officials having other duties instead of officials having to do only with the administration of water laws. The board is composed of the governor, the attorney-general, and the commissioner of public lands, the governor being president. The board elects a secretary, who must be a hydraulic engineer, and is commonly called the State engineer. The secretary, with the consent of the board, employs an assistant, who must be an engineer.

It is made the first duty of the secretary to measure or cause to be measured the flow of the streams of the State and to make additional measurements from time to time for the information of the board in considering applications to appropriate water and controversies that arise in the distribution of water.

Prior to the passage of the law of 1895 there was no provision for defining water rights except as controversies arose, and until 1889 no prescribed procedure for acquiring rights. In fact, it was not settled whether rights could be acquired by appropriation or whether riparian owners alone could use the water of the streams of the State. In 1889 a law was passed providing for the acquirement of rights by the prevailing method of posting and filing notices, building works, and using water. It has since been held that the passage of this law abrogated the riparian rights of lands still belonging to the General Government, and that prior to 1889 rights to water were acquired both by the acquirement of riparian lands and by appropriation, and in case of conflict priority of acquirement was to govern. (Crawford *v.* Hathaway, 93 NW., 791.)

DEFINING RIGHTS.

The first work undertaken by the State board of irrigation after its creation was the defining of existing rights to water.

Preparatory to the adjudication of existing rights the county clerks were required to send to the board transcripts of all claims to water on file in their respective offices. For this they were to receive 5 cents per folio, to be paid by the counties, or they were allowed to send in the original records without compensation. Such transcripts were received from 44 counties, containing 780 claims. In all, about a thousand claims to rights under the old laws have been filed.

No method of making adjudications has been prescribed by law, this matter being left entirely to the board. Rules were at once adopted under which the adjudication is made by the secretary, from whose decision appeal may be taken to the board. In case there is no appeal, the board merely adopts the report of the secretary. As soon as the records were received from the county clerks, blank claim affidavits were sent to all parties having claims on file. The years immediately preceding the passage of this law had been years of great activity in ditch building, but many of these ditches were not completed. The board therefore decided that it should consider their rights along with the others, and, in addition, to determine how much water they were entitled to, fix the time within which the work should be completed and the water put to beneficial use. The blanks sent out therefor contained questions as to the plans of claimants and the time required for carrying them out. The affidavits were to state: The name and residence of the claimant, the purpose of the appropriation, the names of the ditch and stream, the quantity of water claimed, the location of the head gate, the length of the ditch and the sections of land through which it passed, a plat of the ditch and its dimensions, the amount of excavation in cubic yards and the length of fluming, the amount of work done at time of making affidavit, the estimated total cost and cost to date, the description of the land to be irrigated, the date of beginning construction, the dates of completion and of use of water, the dates of first use of water, the area and crops irrigated at time of making affidavit, and the relation which subscriber bore to the work. Blanks for power rights were also sent. Each blank sent out specified the time within which it must be returned properly filled out.

After these claim affidavits are received hearings are set at convenient points. The secretary mails to each claimant, at least ten days before a hearing, a notice of the dates and places of hearings, and if the post-office address of any claimant is unknown the notice is sent to the clerk of the county where the adjudication is to take place. The rules for such hearings are as follows:

> Said hearings shall be held for the purpose of receiving testimony offered by parties in interest, in support of rights claimed, and shall be presided over by the secretary, assistant secretary, or one of the under secretaries of this board, who shall keep a complete record of the proceedings thereof.
>
> All evidence, whether oral or in the form of depositions, shall be submitted in typewritten form. If oral, it shall be taken down and transcribed at the expense of the claimant offering the same.
>
> Claimants may appear in person or by attorney, but appearance must be made on the day or days specified for the hearing for the county within which the said claim is located.
>
> Claimants having filed with the secretary of this board, ten days previous to date of first hearing announced, claim affidavits in the form prescribed and entitled "Claim for the waters of the State of Nebraska," need not appear at said hearings unless they wish to offer additional testimony in support of their claims.

Points of law made by claimants or their attorneys, together with the authorities cited in support of the same, must be submitted in typewritten form.

The record in the case of each claim shall consist of—

First. The original notice filed with the county clerk.

Second. A claim affidavit signed and verified.

Third. Additional testimony offered at hearing in support of claim.

Fourth. Points of law and authorities cited in support of same submitted in writing.

Fifth. Decisions of secretary.

All matters set forth in claimant's notice of appropriation posted at the proposed point of diversion and filed with the county clerk in accordance with the provisions of the irrigation law of 1889 and the claim affidavit in the form provided by the State board of irrigation, entitled "Claim for the waters of the State of Nebraska," filed with the board in support of claim, together with any other ex parte affidavits offered for the same purpose, shall be accepted as true, provided there shall be no contest in reference thereto, or that the contrary shall not appear upon investigation by the board or an officer thereof upon its own motion.

In case a claim affidavit has not been filed in the form and at or before the time prescribed with the State board in support of a claim deemed to have accrued prior to April 4, 1895, failure to make appearance and file such affidavit at the time and place of hearing set for the county within which such claim is located shall be deemed to constitute an abandonment thereof.

Anyone wishing to contest a claim files with the board a notice stating the ground for contest and proof of having served notice on the opposite party. The latter has fifteen days in which to answer with proof of service on contestant, who then has ten days in which to reply. If contestee is a nonresident, the board is notified, and notice is given by publication. When issues have been made up in this way, the secretary sets a place and date for hearing the contest and notifies each party. These hearings are held by the secretary, as are the original adjudications.

Copies of decisions of the secretary in adjudications or contests are mailed to all parties in interest on the day on which they are made. Anyone dissatisfied with such a decision may, within ten days after receipt of a copy, ask for a rehearing before the secretary, setting forth the grounds for the petition. No appeal may be made to the board until such an application for rehearing has been made and acted on by the secretary. Any time within fifteen days after a decision of the secretary on rehearing appeal may be taken to the board. The appeal must be accompanied by a typewritten brief and proof of service on the parties adversely interested. All pleadings, affidavits, etc., must be typewritten. The review by the board will be by brief. Rehearings before the board may be applied for at any time within forty days. Appeals may be taken from the rulings of the board to the courts, but very few have been taken.

All decisions of the secretary from which appeals are not taken are affirmed by the board.

Surveys made by the secretary or his assistants before adjudications are not required, as they are in Wyoming, but have been made in many cases, although not always.

The claims under the old law were nearly all adjudicated between April 4, 1895, when the law went into effect, and November 30, 1898. The secretary, in his report for 1897-98, states that at that date there were 995 claims on record, 947 of which had been passed upon, leaving 48 cases to be disposed of. In the period covered by the report there were also 12 rehearings before the secretary and 1 appeal to the board from the secretary.

The law provides that within thirty days after the determination of the rights on any stream the secretary shall issue certificates setting forth "the name and post-office address of the appropriator, the priority number of each appropriation, the amount of water appropriated, and the amount of prior appropriations, and if such appropriation be for irrigation, a description of the land to which the water is to be applied, and the amount thereof." On account of the large number of uncompleted ditches at the time the adjudications were made it was impossible to comply with this law, since both the amount of each appropriation and the amount of prior appropriations depended on the areas reclaimed by these uncompleted ditches.

In 1900 the secretary decided to make an effort to get proof on the rights which had been determined conditionally in previous adjudications. The time allowed for many of these had expired, and blank proofs of appropriation were sent to the holders of all such rights. In response to this, proofs were received in 189 cases. In some cases the descriptions were so faulty that personal examination was necessary, but in most of them it was fairly accurate. The proofs were put on inspection at specified places, in order that contests might be filed. Up to that time but one certificate had been issued. During the year 1900 seventy-six more were issued. These are sent to the county clerks, and by them recorded and transmitted to the owners on payment of the recording fee, which may not exceed 75 cents.

The practice of the board in adjudicating the rights of uncompleted ditches has been overruled by the supreme court. (Farmers' Irrigation District *v.* Frank, 100 NW., 286.) In these adjudications the secretary took testimony as to the plans of the appropriators and fixed the amount of the appropriation at one-seventieth of a cubic foot per second for each acre which it was proposed to irrigate. In each case, however, this clause was added:

> The amount of water appropriated shall not exceed —— cubic feet per second of time; neither shall it exceed the capacity of said ditch or canal nor the least amount of water that experience may hereafter indicate as necessary for the production of crops in the exercise of good husbandry; and, further, said appropriation, under any circumstances, shall be limited to one-seventieth ($\frac{1}{70}$) of a cubic foot per second of time for each acre of land to which water is actually and usefully applied on or before ——— (date fixed for completion).

The court held that the board exceeded its powers in so far as it went beyond determining the rights acquired at the time of the adjudication; that in going beyond this it was granting rights, which it had no power to do. From this premise the court reached the conclusion that the owner of such a canal had the right, dating from the time of beginning work as fixed in the adjudication, to the full amount to which the board had stated right would be acquired if it was put to beneficial use within the time fixed. In other words, the decision was that the board could not grant a right, but that it did grant a right which was good. Not only that, but the court declared vested rights which the board had made conditional upon the beneficial use of the water. Very few of the large canals which were uncompleted at the time of adjudication have yet been extended to water the area specified, yet under this decision they hold rights to the full amounts stated in the findings of the board unless it is proved that the rights have been abandoned. The secretary has not, however, issued certificates to the holders of such rights, and when requested to do so he merely certifies to what the records of his office show.

ACQUIREMENT OF RIGHTS.

The party wishing to acquire a right to water in Nebraska applies to the secretary of the board. The requirements for this application are as follows:

> Said application shall set forth the name and post-office address of the applicant, the source from which said appropriation shall be made, the amount thereof as near as may be, location of any proposed work in connection therewith, the time required for their completion, said time to embrace the period required for the construction of the ditches thereon and the time at which the application of the water for beneficial purposes shall be made, which said time shall be limited to that required for the completion of the work when prosecuted with diligence, the purpose for which water is to be supplied, and if for irrigation a description of the land to be irrigated thereby and the amount thereof and any additional facts which may be required by the State board.

If the application is in any way defective it is returned to the applicant for correction. The secretary has the right to approve the application for a less amount of water than is applied for, for a less area of land or may limit the time for completing the work. He is required to refuse an application if there is no unappropriated water in the source of supply or if a prior appropriation has been made to water the same land or if it is deemed detrimental to the public welfare. Appeal may be had from the decision of the board to the district court. In a recent case, where it was reasonably sure that an appeal would be taken whichever way the secretary ruled, the board took up the original application before the secretary had acted on it and decided the case. Appeal was at once taken to the court. The case of Farmers' Irrigation District *v.* Frank, cited above, was also an appeal from the ruling of the board. In that case the question was whether the board could approve an application for the irrigation of land which was covered by a previously approved application, and the court held that it could not. The language of the law is "if a prior appropriation has been made to water the same land." The question on which the case hinged was whether the securing of the approval of an application for water to irrigate a given tract of land is the "appropriation of water" for that tract. The ruling of the court is to the effect that it is. In Nebraska, as in Wyoming, there is no requirement that the applicant own the land covered by his application or that he show any agreement with the owner. The effect of this ruling is, therefore, that one person can secure the right to water the land of another, and the latter is barred from providing his land with water in any other way. The ruling in Wyoming is that a permit is not exclusive (see p. 29).

For a few years after its organization the board held that until existing rights were adjudicated it had no means of determining whether there was unappropriated water in any stream, and therefore took no action on applications other than to receive and file them. A circular letter was sent to each applicant explaining the situation and stating that if he were sure there was unappropriated water the board would not seek to prevent his proceeding with construction and that such construction should not in any way prejudice his rights. In many cases canals were built under these conditions. Since the old rights are very largely adjudicated, applications are now acted on promptly, the work being practically kept up to date.

The application blanks contain four township plats, and the location of headworks and the line of canal must be shown on these, but regular maps are not required until six months after the approval of the application. When an application is received the engineer examines the situation himself, or has some one else, usually one of the water officials, do so, and bases his approval or disapproval on this report. One case is reported where an under secretary reported that the plan was impracticable and the application was rejected.

The rejection of applications seems to be much more common in Nebraska than in the other States. The report of the secretary for 1899 and 1900 states (p. 9) that in those two years 210 applications were allowed and 126 dismissed. In the succeeding two years 74 were allowed and 17 dismissed. The right of the board to reject applications has never been passed upon by the courts. In the one case of appeal from the secretary this question was not passed upon. This right has been denied in Utah and Idaho (see pp. 53, 69), and in Wyoming is seldom exercised.

Up to September 15, 1905, there had been 800 applications approved under the law of 1895.

Rights to store water and to appropriate water for power purposes are initiated in the same way as ditch rights. There is no provision for inspection to see that work is commenced within six months after the approval of an application, and this question would arise only in case of contest.

Before the time for the completion of works under a permit a blank "Proof of appropriation" is sent to the holder of the permit, with a circular letter stating when proof must be submitted, and giving directions as to filling the blank and making a map showing the lands irrigated.

The proof of appropriation consists in a sworn statement showing the name and address of the appropriator, when works were begun and were completed, description of works, areas irrigated the first year and in subsequent years, legal description of lands irrigated, period in each year when water is used, period when water supply is short, and the amount of the appropriator's interest in the works

On the receipt of this sworn statement the secretary or some representative examines the works, sometimes making surveys, and reports on the case. If the proof is not contested and the works and areas irrigated are found as represented, a certificate is issued.

If no response is made when proof of appropriation and notice of expiration of time for completion of works are sent, the secretary inquires into the circumstances personally or through some of his assistants. If this examination shows a failure to comply with the approved application, the permit is canceled.

A party wishing to change his point of diversion must apply to the secretary and secure a permit before making the change. On receipt of such an application the secretary makes an examination to determine whether others will be injured by the change before the application is approved. The applications received have been mostly relocations of head gates rather than transfers of use to new locations, but this provision covers transfers as well. This puts upon the one wishing to make the transfer the whole burden of proving to the satisfaction of the secretary that the rights of others will not be injured, instead of leaving those injured to bring action to prevent the transfer.

DISTRIBUTION OF WATER.

The system of distributing water in Nebraska is similar to that in Colorado and Wyoming, except that the officials have different titles. The State is by law divided into two divisions, and the State board of irrigation has authority to divide these into districts upon petition of those interested. Each of these two divisions have been divided into six subdivisions, and five districts have been created.

The State board, through its secretary, has general authority over the distribution. Each of the divisions has an under secretary who has supervision of distribution within his division, and in each district there is an under assistant, who has immediate charge of distribution, under the direction of the secretary of the board and the under secretary of his division.

Ditch owners are required to maintain head gates and flumes to the satisfaction of the under secretary of the division, who is to serve notice on the owners when he requires their construction. If owners neglect to put them in, the under secretary is to notify the county commissioners, who are to put them in, and in case the owners neglect to repay the county the under assistant is to turn off the water. No cases have ever come up under this law. In the other States it has been found more effective to have the water turned off on the refusal of the ditch owner to put in the structures required. Any other system allows delay greatly to the advantage of the person refusing to obey the order.

Interference with a head gate which has been set by an under assistant is punishable by a fine not exceeding $200, or imprisonment not exceeding three months. Under assistants have power to make arrests, and when one is made the under assistant making it must make complaint before the proper justice of the peace. There is no provision similar to that in Colorado and Wyoming, making the use of water from a ditch which has been closed prima facie evidence of having opened the gate. There have been a few arrests, and in one case the under assistant was sued for damages for having closed a gate. This case was never brought to an issue.

MISCELLANEOUS DUTIES OF SECRETARY OF BOARD.

The approval of the secretary must be had for all dams over 10 feet in height. Only a few have been submitted. There is no provision for inspection to insure the carrying out of the plans as approved.

The stream gaugings provided for by law have been carried on in cooperation with the United States Geological Survey. The Survey pays the gauge readers, and the secretary makes the gaugings. Ten regular stations are maintained on the Platte, Loup, and Republican rivers. Other gaugings are made by the secretary as he has opportunity.

Ditch owners selling water are required to maintain measuring devices made on specifications approved by the secretary of the board, but no cases have come up under this provision.

The same is true of the provision that the secretary is to determine what deductions shall be made for losses by seepage and evaporation when water is turned into a natural channel to be diverted below.

In 1905 a law was passed requiring the secretary to furnish counties with bridge plans whenever requested to do so, the cost of the plans to be charged against the county. Three thousand dollars was appropriated for this work, this fund to be a revolving fund, since expenditures are to be repaid by the counties. The secretary is having a series of standard plans made.

RECORDS OF THE STATE BOARD OF IRRIGATION.

For each right originating before the passage of the present law there is in the office of the board a bound record consisting of a copy of the original notice filed, the statement filed under the law of 1895, the testimony taken at the hearing by the secretary, and the opinion of the board allowing the claim. This opinion describes the land and the ditch and gives the acreage. There were in September, 1905, 1,015 of these records. Each of these is given a docket number, by which reference is made to the case.

Applications are recorded as they come in. If they are sent back for correction, the changes are written in on this record, but not in such a way as to show what is original and what is correction. Each application is numbered as it is received.

The main facts regarding rights of both classes are shown in books in which the adjudicated rights and the applications occur in numerical order, being indexed by names in the front of the book. The column headings indicate the nature of this record. They are as follows:

(1) Number; (2) name of stream; (3) name of claimant; (4) post-office address; (5) name of canal; (6) use to which applied; (7) second-feet applied for; (8) location of head gate, section, township, range, and county; (9) date filed; (10) date of approval; (11) date of dismissal; (12) affirmed by board, date; (13) date of priority; (14) certificate number; (15) priority number on stream; (16) priority number on watershed; (17) estimates by claimant, length, cost, and area covered; (18) date of completion of works; (19) date of completion of application of water; (20) extension of time; (21) proof of appropriation filed, date; (22) maps—case, number; (23) reports of assistants—volume, page; (24) field notes—volume, page; (25) record—volume, page; (26) relocation—volume, page.

Record is also kept by streams on sheets showing the data which is given in the applications or proofs filed.

The maps filed with the proofs and applications are indexed by the names of the owners, and the books in which all rights are kept by docket or application numbers give the number of all maps relating to those rights. There is also an index of drawers in map cases, by numbers, showing what is in each. All of these indexes of maps are in a single book. The numbers given maps show where they should be kept, so that if any map is left out of the case it can be put in its proper place without trouble. For example, the number 1 2 10 shows that the map belongs in drawer 1, compartment 2, and is the tenth map from the bottom.

The secretary is making township maps of the State on the scale of 2 inches to the mile, showing the streams and ditches and the lands irrigated by each ditch. On these maps each ditch bears its name and the docket number, if it has an adjudicated right, and the application number, if it was built under the present law.

FEES.

Until 1905 no fees were charged by the board of irrigation. In that year a law was enacted providing that fees be collected by the secretary as follows: For filing and examining application, $2; for recording any other water-right instrument, $1 for the first 100 words and 15 cents for each additional folio; for copying maps or plats, 40 cents per hour for the time used; for making certified copies of any documents, 15 cents per folio and $1 for each certificate attached; for issuing certificates of appropriation, $1. No provision as to the disposition of the funds is made, but they have been turned into the general fund of the State. When oral testimony is given at a hearing, the party in whose interest it is given must pay the stenographer 20 cents per folio. The amount of the stenographer's fees was large during the years when adjudications were being made, but these have practically ceased.

APPOINTMENT, TERMS, AND SALARIES OF OFFICIALS.

The secretary is elected by the State board of irrigation. The term is two years, and the salary $2,000 per year. He may appoint an assistant at $1,200 per year and other assistants at an expense not to exceed $500 per year.

The under secretaries are elected by the board for terms of two years. They receive $5 per day, not to exceed $800 per year. This is paid by the State.

Under assistants are elected by the board for a term of two years. They receive $5 per day for the time put in, paid by the county where the work is done. They can not receive more than $500 per year.

IDAHO.

The office of State engineer was created in 1895, in connection with the acceptance of the conditions of the Carey Act. The engineer is required to examine plans submitted under that act to determine whether they are feasible and beneficial to the public; whether there is unappropriated water in the source of supply; whether he has approved a permit for the appropriation of the water to be used; whether the works planned are of sufficient capacity to properly supply the land; whether the cost of construction is reasonable; whether the maps filed comply with the regulations of the Department of the Interior and with the regulations of the State engineer's office, and whether the lands applied for are desert in character. If necessary, in order to determine any of these things, the engineer may make surveys. He reports his findings to the State land board, which has the approval of plans under the Carey Act. The construction of works under this law is also subject to inspection by the State engineer. He is required to measure the flow of streams, locate and survey reservoir sites, and give estimates of capacity and cost. All parties wishing to build dams over 10 feet high are required to have their plans approved by the engineer, and he is also required to inspect existing dams over 20 feet high.

Since 1901 irrigation district plans also have been subject to the approval of the State engineer. The maps, estimates, and descriptions of proposed districts are submitted to the engineer sixty days before the hearings on the organization of the districts before the county commissioners. The engineer examines the plans and in some cases goes over the ground and reports to the county commissioners. If the engineer reports adversely, the matter is dropped, except that the petitioners may amend their plans in such a way as to meet the approval of the engineer. Idaho has gone further than any other State in aid of irrigation districts, paying benefits assessed on State lands included within the boundaries of such districts, and, on the other hand, it is the only State requiring that district plans be approved by any State official.

Up to 1903 the engineer had nothing to do with the acquirement of rights or the distribution of water, his duties being chiefly making general surveys of the water resources of the State and in connection with the Carey Act projects and irrigation districts. In that year an attempt was made to provide by law a complete system of public control of the water supply of the State with the State engineer at the head.

DEFINING RIGHTS.

The adjudication of rights was left with the courts, as it was before, but provision was made for the beginning of actions for adjudication of rights by water commissioners and for the making of surveys and maps by the engineer on request of the court whenever any action for the adjudication of water rights was brought. This law provided for the bringing of actions by the commissioner on streams whose waters had been partly adjudicated, but made no provision for streams where the rights were entirely undefined. The provision for the bringing of actions by the water commissioner was declared void in Bear Lake *v.* Budge (75 Pac., 615), the court holding:

> Under the police power of the State the legislature can not authorize a public officer to bring a suit to settle private rights to the use of water or the priority of such rights.

The provision for the court calling upon the engineer to make surveys when actions are brought by private parties has, however, been upheld. (Boise City Irrigation and Land Company *v.* Stewart, 77 Pac., 25.) But this provision is held to be merely directory, not mandatory. The engineer has therefore no necessary connection with the adjudication of water rights, since the court may call on him for the surveys or not, in its discretion.

In two cases the court has called on the engineer for surveys—one for the settlement of rights on the Boise River and one for the settlement of rights on the upper Snake River. In each case the engineer has made the measurements and prepared maps. The maps of the Boise are on a scale of 600 feet to the inch, the canals and larger laterals and irrigated lands being mapped from surveys. The areas served by the various canals are shown in different colors, and the names of the owners of all lands are placed on the map. In addition, statements are made up showing the location and capacity of each lateral, the name of the owner of each legal subdivision of land, the crops raised, the areas irrigated, and the additional area irrigable. The statements for each canal are bound together, and on the cover the statements contained are summarized.

The cost of the surveys, maps, and statements for the Boise River was $10,704.60, and the total area irrigated 102,505.4 acres, and the additional irrigable area under existing canals 127,421.9 acres. This makes a cost of 10.4 cents per acre irrigated or 4.7 cents per irrigable acre for which water is claimed.

The surveys on the upper Snake River covered 290,679 acres of irrigated land and an additional area of 502,501 acres of irrigable land, at a total cost of $28,000. This is at the rate of 3.5 cents per acre for the entire area or 9.6 cents per acre irrigated. One-half the cost of the surveys on the Snake River was borne by the United States Geological Survey and one-half by the State engineer's office, the work being in charge of the engineer.

The costs of these surveys are to be assessed by the court against the parties to the adjudication pro rata. There was, however, no appropriation to cover the expense of surveys, making it necessary for some one to advance the money. In the case of the surveys already made, some of the banks of the State advanced the cost upon warrants issued by the State engineer and are holding them until the cases are settled.

The surveys and statements are filed with the court, and the question of their status as evidence has been raised. In Boise City Irrigation and Land Company *v.* Stewart, the State supreme court held:

> I think it was the intent of the legislature to authorize the court to accept such evidence just the same as any other evidence is accepted and to consider it with all the other evidence in the case, and if it is shown to be correct to accept it; otherwise to give it such effect as under all the evidence the court may think it entitled to.

Judge Stewart, the defendant in this case, before whom the Boise River case is being tried, has intimated that he will not accept the surveys of the engineer as final on the acreages irrigated, where the testimony shows that areas other than those shown on the maps as irrigated have been irrigated in previous years. It has also been held that if the maps are incorrect as to any party's canal, he can not be compelled to pay for the survey.

In the Boise River case the court has requested the engineer to make measurements of return seepage, the measurements to be used in preparing the decree. During the season of 1905 the water supply in the Boise River was very short, and the court issued a temporary decree providing that the water be divided among the canals of the valley on the basis of the acreage served by each, disregarding priorities entirely. This was acquiesced in by all parties concerned, but not without some complaint. By this means the orchards and perennial crops have been kept alive throughout the valley, and the water undoubtedly did much larger service than it would have done if priorities had been recognized. It is claimed also that the forced economy of the season of 1905 will do a great deal to promote more economical use in the future.

It is unfortunate that the provision for the foundation of any system of public control of water—a list of existing rights—is not provided for in the Idaho law. The water commissioners can not properly enforce undefined rights, and neither the engineer nor an intending irrigator can tell how much unappropriated water there is in any source of supply until the rights to that supply are adjudicated. If the principle announced by the supreme court that a State official can not bring an action for adjudication is maintained it will be impossible to provide for the complete list of rights, which is necessary for the orderly public control of the waters of the State. Adjudications will naturally take place from time to time, and rights can not now be acquired without being properly defined. There will therefore be a gradual approach to a complete list, and perhaps after many years all rights may be defined.

There is, however, provision for compiling and publishing lists of the decreed rights to the streams of the State. The clerks of the district court were required to prepare at the expense of the counties and send to the State engineer copies of all water-right decrees on file. The engineer records these in books kept for that purpose and classifies them, placing all rights to the water of one stream and its tributaries together. These classified rights are kept in a card index.

Certified copies of the allotments on each stream are furnished to the water commissioner having jurisdiction over it. The water commissioner then prepares for each stream a list of the rights, numbered in the order of their priorities, and has it printed in pamphlet form and distributed to the water users interested. These pamphlets have been prepared for the streams where decrees have been rendered.

ACQUIREMENT OF RIGHTS.

Since 1903 the engineer has had control of the acquirement of rights. Any party wishing to acquire the right to use any of the public waters of the State must make application to the engineer in proper form. This application must set forth:

> (1) The name and post-office address of the applicant; (2) the source of the water supply; (3) the nature of the proposed use; (4) the location and description of the proposed ditch, channel, or other work and the amount of water to be diverted and used; (5) the time required for the completion of construction of such works, which in no case shall exceed five years from the date of approval of application; (6) the time required for the complete application of the water to the proposed use, which must be within four years after the date set for the completion of such works.
>
> The application shall be accompanied by a plan and map in duplicate of the proposed works for the diversion and application of the water to a beneficial use, showing the character, location, and dimensions of the proposed reservoirs, dams, canals, ditches, pipe lines, and all other works proposed to be used by them in the diversion of the water and the area and location of the lands proposed to be irrigated.

When the works to be built have a capacity of less than 25 cubic feet per second the maps filed with the application may be made by the applicant, but when the capacity is more than 25 cubic feet per second they must be accompanied by a certificate of the surveyor who made them.

When an application is received the engineer indorses on it the date of its receipt and records it in a book called the "Starting book." If the point of diversion is not given or if the filing fee does not accompany the application it is not recorded and given a number. It is not then considered as having been received at all, except that it will be returned to the applicant with a statement of what is lacking. Applications which do not comply with the law or the regulations of the engineer's office are returned for correction and must be returned corrected within sixty days.

The engineer is required to approve all applications which are in proper form and which contemplate a beneficial use of the water applied for, and the application thus approved constitutes a permit. This provision relieves the engineer of a great deal of the responsibility which is placed upon engineers in other States where they are given power to reject applications if there is no unappropriated water in the source of supply, if the granting of them is contrary to public policy, or if the applicant does not show his financial ability to carry out the proposed plans, but it makes this feature of the work of the engineer of just that much less value. Where the engineer is required to reject an application if there is no unappropriated water in the proposed source of supply, his approval gives some assurance that there is water to which the applicant can secure a right, while in Idaho it means no more than that the application was in proper form, placing on the applicant the burden of finding out whether his permit is of any value. This would seem to be a proper State function, since the individual has not the means of investigating the water supply and the existing rights, as has the State; but the law is at least consistent. As has been shown in the previous pages, there is no provision for securing a complete list of all rights to water from any stream, and without such a list neither the engineer nor the applicant can tell from the records whether there is unappropriated water in any stream. In many cases it will of course be a matter of common knowledge that a stream is or is not fully appropriated, and there may be little danger of injustice so far as the applicant is concerned. The filing of applications, however, provides a record of the time of initiating rights, since if the work is carried out in accordance with the law and the regulations the right dates from the date of filing, and the requirement of the approval of an application by the engineer before construction can begin prevents the initiation of any rights without a public record.

The works provided for in an application must be completed within five years, and the water must be applied to beneficial use within a further period of four years, but the engineer in approving an application may require that the work be done in shorter periods. One-fifth of the work must be done at the expiration of one-half of the time allowed for completion of works. Works having a capacity of less than 25 cubic feet per second must be begun within sixty days from the approval of the application, and the holder of a permit for more than 25 cubic feet per second must within sixty days of the issue of the permit file a bond, the amount of which is fixed by the engineer, not exceeding $10,000, conditioned upon faithfully carrying to completion the works specified in the permit. There is no inspection to determine whether this has been done. Whether work is begun in proper time and carried on with proper diligence will be brought up only when some adverse claim arises, when the applicant will be required to prove compliance with the law. One such case has arisen and is still pending. The provision for filing bond conditioned on completion of the work was enacted in 1905, and there has been little opportunity to observe its workings. Its natural result will be to prevent filings for the purpose of blocking some other enterprise or for the purpose of selling worthless "rights" based only on a permit from the engineer. The requirement that duplicate maps be filed with the application will have the same effect, since it adds to the expense necessary to securing a permit. If surveys must be made, maps made in duplicate, and bonds filed, the danger of filings for any but legitimate purposes will be lessened. Another provision having the same tendency is the filing fee of $1 for the first cubic foot per second filed on and 10 cents for each additional cubic foot per second. While 10 cents per cubic foot per second is a small fee, it is sufficient to retard the filing of applications for extravagant amounts of water.

There has been but one appeal to the courts from the rulings of the engineer on an application, and that was settled out of court. If the matter had remained in the court, the engineer would have placed the matter in the hands of the attorney-general. Most of the applications made have to be returned to the applicants for correction, and as a rule they are corrected in accordance with the suggestions of the engineer and returned. Many applicants employ attorneys to make out their papers, but as a rule these do not meet the requirements any better than the others.

Before the expiration of the time allowed for the completion of works under a permit the holder must submit proof of the completion of the works in accordance with the permit. At least sixty days before the expiration of the time allowed the holder must send to the engineer a notice that he will be prepared to submit proof of completion on a stated day, and if the works are to carry more than 50 cubic feet per second an engineer's certificate must be submitted with the notice of proof. In practice the engineer notifies the holder of the permit of the time when his works should be completed and of the time when he should notify the engineer of his readiness to submit proof. The notice to the engineer is sent on blank forms provided by the engineer and gives the date when proof will be submitted, the name and post-office address of the holder of the permit, the number of the permit, the purpose for which the water is to be used, the capacity of the works, the area of land for which the water is available for canals carrying more than 50 cubic feet per second, a certificate from an engineer that the statements made in the notice are true, and the name of the newspaper in which the permit holder wishes notice of his submitting of proof published.

Upon the receipt of such a notice the engineer orders it published for a period of four weeks in the newspaper designated by the holder of the permit, the notice to contain also the date when proof will be submitted to the engineer and the place where it will be submitted. This publication is at the expense of the applicant, and the average cost up to this time has been about $5. The engineer has printed forms for these notices, for letters transmitting them to newspapers, and for acknowledgment of their receipt by the publishers. The permit holder may submit affidavits from two engineers as to dimensions and grade of ditch, and the State engineer may demand profiles and cross sections, and if the works are completed may order the water turned into them for the purpose of measuring it. The holder makes a sworn statement and submits depositions from two witnesses; the engineer examines the works and makes a report on their condition. So far there have been no serious differences between the statements submitted and the results of the measurements made by the engineer. When differences occur further examination is made and agreement is reached informally. There were about fifty proofs to be taken in September, 1905, and the number is constantly increasing. Any party feeling aggrieved at the action of the engineer may appeal to the courts, but there have been no such appeals. Others than the claimants have paid very little attention to the submission of proof. If the works have been completed in accordance with the permit, the engineer issues to the permit holder a certificate of the completion of the works.

Upon the issuing of a certificate of completion the holder pays to the engineer a fee of $5 for a canal having a capacity of 10 cubic feet per second or less; for larger canals the fee is at the rate of 30 cents for each cubic foot per second.

A similar procedure is followed for making proof of the application of the water to beneficial use, the cost of advertising being about the same. Maps are made by representatives of the engineer showing the irrigated land. There have been no contests or appeals in connection with this. When beneficial use has been proved the engineer issues to the party a license which gives the numbers of the application, the permit, and the certificate of completion, and further defines the right, as follows:

> Now, therefore, by virtue of the authority vested in me by the laws of the State of Idaho, I hereby grant and confirm to ———, of ———, the holder and owner of said permit No. ——, a perpetual right, dating from ———, to the use of —— cubic feet per second of the waters of ———, in the county of ——— and State of Idaho, or so much thereof as may be necessary for the purposes hereinbelow mentioned, to be diverted at ——— and conducted to and upon ——— for the purpose of ———, subject, however, to the laws of the State of Idaho applicable to a license for the use of the waters of the State, and subject, also, to the local or community customs, rules, and regulations which have been or may be adopted from time to time by a majority of the users from a common source of supply, canal, or lateral from which such water may be taken, when such rules and regulations have for their object the economical use of such water.

Up to September 5, 1905, twenty-two such licenses had been issued covering 2,413.9 acres, an average of 110 acres per license, showing that they were all for small works. The law has been in effect only a little more than two years, and naturally only small works have been completed.

Where a canal supplies water to others than its owners, the license is issued to the owners rather than to the landowner. A fee of $2 for each legal subdivision of 40 acres or fraction thereof is charged for the license when the water is used for irrigation, and a fee of $5 when the water is used for some other purpose; but when two or more users, whose lands join or who take water from a common lateral, join in submitting proof the fee is $1 for each legal subdivision of 40 acres or fraction thereof.

The total fees for acquiring a right to water from an Idaho stream for a homestead of 160 acres are as follows:

Cost of securing water rights in Idaho.

Filing fee with application (3.2 cubic feet per second)	$1.30
Fee for examining works for completion	5.00
Advertising date of proving completion	5.00
Fee for examining land for application of water to beneficial use	8.00
Advertising date of proving beneficial use	5.00
	24.30

All of these fees go to the general fund of the State, as similar fees do in the other States. In some States there is a desire on the part of the engineers to have the fees retained in the engineers' offices, to allow of an extension of the work done. This is not considered very important in Idaho, however. It is felt that if the fees are large the legislature will make larger appropriations than otherwise, and the result will be the same as if the fees were retained in the office.

DISTRIBUTION OF WATER.

For the purpose of administering and controlling the public waters, the State is divided into three water divisions, and for each of these divisions there is a water commissioner appointed by the governor and confirmed by the senate. The State engineer and the three water commissioners constitute the State board of irrigation. This board makes rules in regard to making proof of completion of works and the application of water to beneficial use, and all needful rules for the distribution of water. Each commissioner must reside in his division, and has immediate direction and control of the water masters and of the distribution of the water in his division, under the general supervision of the State engineer. The commissioner is also, when requested by the engineer, to take proof of completion of works and of the application of water to beneficial use. The commissioners are to serve six years, the terms being so arranged that one will be appointed every two years. The commissioner of water division No. 3 is secretary of the board.

The board, in addition to making rules regarding making proof and distribution of water, is to divide the State into districts for the distribution of water. These districts are to be created as necessity for them arises, the first ones being made to embrace the streams whose waters had already been allotted by the courts, and others are to be created as the streams are adjudicated. Any company or association not selling or renting water may have a water master appointed by the water commissioner. Water masters are appointed by the water commissioners and serve for one year, but on adjudicated streams where the extreme points of diversion are not more than 20 miles apart the water users may select a water master. A community having unadjudicated rights and using a stream or ditch in common may also elect a water master for their supply. Each water master is required to give bond in the sum of $500, conditioned on the faithful performance of his duties. He is also responsible for the illegal acts of any deputies he may appoint. The commissioner may remove any water master for failure to do his work, upon complaint made to him in writing.

Water masters are required to make reports to the water commissioners as ofter as deemed necessary by the commissioners. These reports show: The amount of water necessary to supply all ditches, canals, and reservoirs in the district; the amount of water available for this purpose, what ditches or reservoirs are at times without sufficient water, and an estimate of the probable supply for the period before the next report. From these reports made by the water masters the water commissioner determines whether the water is being properly divided between the districts receiving water from a common supply, and if not he orders such change in the distribution as will enforce priorities regardless of district lines. The reports of the water masters are kept on file in the State engineer's office.

The water masters divide the water within their districts according to the priorities of rights, under the direction of the water commissioners. Any person who willfully changes a gate set by a water commissioner is subject to a fine not exceeding $100, or to imprisonment not to exceed six months, or both; and the water masters and their deputies have power to make arrests for such offenses. They are also required to make complaint in writing and under oath before the proper justice of the peace against the person arrested. Up to the present time there have been no arrests for interfering with gates, although there has been some friction. It has been the policy of the water officials to get along with as little trouble as possible until the water users of the State come to realize the advantages of the enforcement of the law.

To aid in a proper distribution of the water, all appropriators are required to maintain head gates and measuring flumes in their ditches. Plans for these measuring devices are furnished by the State engineer. If the water users do not put them in after ten days' notice to do so the water commissioner is to put them in, and present his bill to the county commissioners, who, in turn, present it to the party who has failed to put in the devices. If the owner neglects for ten days to pay the bill the water commissioner is to shut off his water until the bill is paid. Little has been done under this law thus far for the same reason that arrests are not made for changing head gates. It is not considered desirable to make the law obnoxious to the water users, but rather to create a sentiment in favor of its enforcement, which is gradually being accomplished. It has been suggested that the method of collecting the cost of measuring devices by the water commissioner is cumbersome. The appropriator has first ten days in which to comply with the order of the commissioner, then the commissioner puts in the measuring device. It may then be nearly three months before the bill can be presented to the county commissioners, as it is to be presented at a regular meeting and these meetings occur but once in three months. After the bill has been passed upon by the county commissioners ten days more are given before anything is done, then the water commissioner turns off the water until the bill is paid. The irrigating season will be over by that time and the turning off of the water is no hardship. There is no provision for reimbursing the water commissioner if the appropriator still refuses to pay. Under this provision the appropriator may continue to use water for a whole season after being ordered to put in a measuring device, before he can be forced to do anything. It would seem that the provision for collecting the pay of water masters might well be extended to the expense of putting in measuring devices—have the county pay the bill and tax the costs against the land served by the ditch.

COST OF ADMINISTRATION.

The salary of the State engineer is $2,000 and is paid from the general fund of the State. The appropriation for the expenses of the office for two years, 1905–1907, was $7,500.

The salary of the water commissioners is $10 per day for the time actually employed, which shall not exceed one hundred and eighty days in any year. For services as a member of the State board of irrigation the commissioner is paid by the State, out of the general fund. The board holds one meeting each year, which can not exceed five days, limiting the amount which the State is to pay each water commissioner to $50 per year. For services in supervising the distribution of water the commissioner is paid by the county where the service is rendered, from the current expense fund of the county.

Water masters receive not to exceed $4 per day for each day actually employed, and assistant water masters not to exceed $3 per day. The water master prepares a sworn statement of the time put in by himself and his deputies, and the volume of water, stated in cubic feet per second, he has delivered to each user each day, and describes the lands to which the water was delivered. The pay of the water masters is charged against the land receiving water in the proportion that the water received by each tract bears to the whole amount of water distributed. The statement is to show the proper apportionment of the expenses among the users and is to be filed with the auditor and recorder of the county or counties in which the water was delivered. The bill is to be paid by the county commissioners and added to the taxes on the land receiving the water. When water is distributed to an organized canal company, the cost of distribution is taxed against the canal, and no canal is exempt from the payment of such taxes. The water commissioner's reports are made on regular blanks supplied by the State engineer's office. These show in columns the names of ditches, the priorities, the names of the owners, the descriptions of the land, the water delivered in "24-hour second-feet," the cost per twenty-four-hour second-foot, special expenses, and the total cost. The report is summarized in the following form:

Total number of days of water master, at $ — per day............ $......
Total number of days of assistant water master, at $— per day.... ......
Other expenses charged pro rata.................................. ......

Total cost... ......
Total number of 24-hour-second-feet delivered.................... ......
Cost per 24-hour-second-foot delivered........................... ......

MISCELLANEOUS DUTIES OF THE ENGINEER.

Parties wishing to transfer the use of water from the land in connection with which the right was acquired to new land may do so if others are not injured by the transfer, on approval of the transfer by the engineer. He has issued a circluar describing the procedure, as follows:

> Under the regulations adopted by the board of irrigation, an applicant for a transfer of water or point of diversion must present his petition and affidavit upon a form which will be furnished from this office, have the same indorsed by two users of water from the same stream who are not interested in his lands or water rights and who are not related to him in any way, and reported upon by the water master of his stream. He must also, at his own expense, publish a notice (form for which will be supplied by this office) for thirty days in some newspaper published in the county where his point of diversion is located, naming a place and date where objections, if any exist, may be publicly presented against the granting of such a certificate of transfer. Proof of publication of such notice must be presented by the applicant to the officer before whom the hearing is had, at the time and place specified in the notice. If no reasonable objections are offered why the certificate of transfer should not issue, and none is known to the officer, the water commissioner or his authorized agent will certify his approval of the application, which will then be forwarded to the State engineer for his action.
>
> Accompanying the application for transfer the applicant, if not the person or corporation to whom the water right was originally decreed or licensed, must submit an abstract of title of his water right and two (duplicate) maps showing fully and in detail the present point of diversion, course of ditch or ditches, and the lands irrigated, and setting forth the lands to which he desires to transfer the water, and any change in point of diversion or course of ditches made necessary to effect it. These maps, together with the $1 fee prescribed by law for issuance of the certificate, must be placed in the hands of the water commissioner or his agent before or upon the day of public hearing, and the applicant will also be required to pay and discharge all costs incurred in defending his petition at such hearing.

The law allowing transfers provides that "any person owning land to which water has been made appurtenant, either by a decree of the court or under the provisions of this act, may voluntarily abandon the use of such water in whole or in part on the land which is receiving the benefit of the same, and transfer the same to other land." This provision is not altogether clear as to what constitutes abandonment of "the use of such water in whole or in part on the land which is receiving the same." The engineer has placed the following interpretation on this clause:

> If a user of water has acquired the right to a certain amount of the water of a stream through a court decree or license issued from this office and by change of crops more economical method of applying water or otherwise has reduced the amount of water needed for the proper cultivation of the lands to which the water was decreed or licensed, the laws are not clear as to whether or not the State engineer would be authorized to transfer the excess thus saved to other lands or uses. Until, however, this matter is determined by the courts, upon the advice of the board of irrigation, it has been decided to grant certificates authorizing such transfers, provided no one would be injured thereby. At the same time, until this point of law is judically determined it is not recommended that applications be made for such transfers.

In practice, if an application for transfer comes to the engineer approved by the commissioner it is approved by the engineer. Transfers are discouraged by the engineer as much as possible. Twelve applications only had been received up to September 4, 1905.

The engineer is chairman of the State board of examining surveyors, which has charge of the examination of surveyors for license.

RECORDS OF THE ENGINEER'S OFFICE.

Applications are given numbers in the order of their receipt, and a record is made in what is called the "Starting book" showing the name and address of the applicant, the quantity of water applied for, the purpose for which the water is to be used, if for irrigation a description of the land to be irrigated, the location of the point of diversion, the date of receipt, the date of return for correction, the date of return to the office, the amount of fees paid, the amount of the bonds filed, the date of approval, and the permit number. In this book all applications are filed in the order of their receipt. There is also a name index, in which the names of applicants are kept in alphabetical order. This gives the number of the application, and when a permit is issued the number of the permit. Up to the time of the approval of the application, when it becomes a permit, all correspondence regarding it is filed under the application number; when it has been given a permit number it is all transferred to the permit number. The permanent files, containing the maps and all correspondence and other papers regarding rights, are kept under the permit numbers.

All records of rights whether defined by the courts or acquired under the new law are indexed by the source of the water supply and by the legal subdivision of the land irrigated. There is a card index for streams, one for springs, one for lakes, and a miscellaneous one which contains rights which do not come in any of the other classes.

The cards in the stream index have on the top line the name of the stream and the county, and in columns the names of the holders of the rights; for decreed rights, the volumes and pages where they are recorded and the quantities in cubic feet per second; for rights acquired under the present law, the numbers and quantities of the applications, the numbers and quantities of the permits, the numbers and quantities of the licenses; and, finally, for both classes, the month, day, and year from which each right dates. In the land index are guide cards showing the townships and ranges and a card for each section in each township. On the latter cards are columns for the descriptions of the lands, the names of the owners; the volumes and folios where the rights are recorded if decreed by a court; the application numbers, the permit numbers; the numbers, volumes, and folios where the licenses are recorded; the numbers, volumes, and folios where transfers are recorded, if there are any; the volumes of the rights in cubic feet per second, and the dates of the rights. Many of the decrees do not describe the land irrigated, but in many cases the court records show this, and the index is being made up from these where the decrees do not show it.

Licenses when issued are entered at length on the records.

A miscellaneous index includes maps filed under the Carey Act, proceedings regarding irrigation districts, and miscellaneous work of the engineer's office.

UTAH.

In the early history of the Territory of Utah there was a considerable degree of public control of the use of water for irrigation, but there came a period of indifference to this, due probably to the settlement of controversies by the church authorities. This had become so marked at the time Utah became a State (1896) that efforts to secure thorough State control of irrigation resulted only in the recognition of existing rights to water. The next year the office of State engineer was created, but he was given no control of the water supply. He was to examine and report on reservoir sites for the State board of land commissioners, submit plans and estimates for reservoirs, supervise the construction of reservoirs by the State, and examine and pass upon all other irrigation work in which the State had an interest. He was also to keep a record of stream gaugings, and inspect all dams over 10 feet high, and require repairs on those considered unsafe. However, there was in this no element of State control.

In 1901 the duties of the engineer were considerably enlarged, and the authority of the State to regulate the use of water was recognized. Provision was made for the distribution of water by commissioners appointed by the county commissioners, and the State engineer was given supervision over these and required to instruct them in the measurement of water. With a few exceptions the boards of county commissioners failed to appoint water commissioners, and this part of the law was inoperative. The making of surveys and maps of streams and irrigated lands was also added to his duties.

In 1903 a complete system of public control was adopted. The water of the State was declared to be the property of the public, subject to existing rights, and the State engineer was given "general supervision of the waters of the State and of their measurement, apportionment, and appropriation." The law provides in detail for the defining of existing rights, the acquirement of new rights, and the distribution of water by public officials.

DEFINING RIGHTS.

The law is a composite of the Colorado and Wyoming systems, providing for adjudication on the initiative of the State and with the aid of the State, as in Wyoming, but leaving it in the courts, as in Colorado. The State engineer is to make complete hydrographic surveys of the stream to be adjudicated, and collect such other facts as will, in his judgment, aid in ascertaining existing rights. When this work is completed, it is submitted to the proper court, which, after hearings, renders a decree defining the rights to water from the stream. The law provides that such surveys shall be made on each stream in the State, beginning with those most used for irrigation. Only one such survey has been begun, but is not yet completed, and the procedure for determining rights has not, therefore, been tried. It is in outline as follows:

Before beginning the survey of a stream the engineer advertises the time and place of beginning by publication in a newspaper for fifteen days. On the completion of the survey the engineer is to file a written statement with the clerk of the district court of the county in which the stream is situated, and if it is in more than one county, in the court of any one of these counties, and that court has exclusive jurisdiction of the case. This statement is to contain the names and post-office addresses of all parties using water from the stream, so far as they are known to the engineer, and such other facts as he deems necessary. Within thirty days after the filing of this statement the clerk of the court gives notice by publication, to all parties claiming rights to water from the stream, and in writing, to all parties whose names are included in the statement filed by the engineer, that within six months from the date of first publication of this notice they must file written statements setting forth their respective claims to the use of water. The clerk is to send with the notices blank forms for the statements of claims. When returned these are to contain sworn statements, showing:

> The name and post-office address of the person, corporation, or association making the claim; the nature of the use on which the claim of appropriation is based; the flow per sec-

ond of water used and the time during which it has been used each year; the name of the stream or other source from which the water is diverted; the place on such stream or source where the water is diverted, and the nature of the diverting works; the date when the first work for diverting the water was begun, and the nature of such work; the dimensions, grade, shape, and nature of the diverting channel, as originally constructed; the date when the original diverting channel was completed; the date when the water was first used, the flow per second, and the time during which the water was used the first year; the date and nature of each subsequent change made in the original diverting channel; the flow per second of the water used and the time it was used each year between each of the changes so made, and the dimensions, grade, shape, and nature of the present diverting channel; the place where and the manner in which the water was first used; the nature of each subsequent change in the place or manner of use, and the place and manner of present use, and such other facts as will clearly define the extent and nature of the appropriation claimed. If the water claimed to have been appropriated is used for irrigation the statement shall show, in addition to the above-required facts, the area of land irrigated the first year and each subsequent year; the total area at present irrigated, and its location in the section, township, and range wherein it is situated; the character of the soil and the kind of crops raised during the first year of use and the first year after each subsequent change of channel, and during the last year in which the water was applied.

If the water claimed to have been appropriated is used for developing power, the statement shall show, in addition to the above required facts, the number, size, and kind of water wheels employed; the head under which each wheel is operated; the extent of the power produced, and the purposes for which and the places where it is used, and the point where the water is returned to the natural stream.

If the water claimed to have been appropriated is used for mining the statement shall show, in addition to the above-required facts, the name of the mine and the mining district in which it is situated, the nature of the material mined, and the place where the water is returned to the natural channel of the stream.

Within six months from the expiration of the time for filing these statements the State engineer is to tabulate the facts shown by the statements, and file a copy with the clerk of the court and with the clerk of each county in which the stream lies.

Failure to file such a statement bars any party from subsequently claiming any rights, except that parties receiving no notice but by publication may apply to the court for permission to file a statement, and the court may allow this within one year from the date of first publication, if the applicant makes it appear to the satisfaction of the court that he had no actual notice in time to file the statement.

At the expiration of the six months allowed for filing statements the court may appoint a referee or referees to hear the case. All papers are turned over to them, including maps made by the State engineer, and the engineer is to give on request any information he has or copies of any records of his office.

Hearings are to be held at convenient points, notice of the times and places to be given by publication, and to each claimant fifteen days before testimony is to be taken on his claim, in the same manner as summons out of a district court. During all the time of the hearings the maps and statements furnished by the engineer are to be open to inspection. Any interested party may contest the rights of any other person. Referees have power to issue subpœnas for witnesses. All testimony is to be stenographically reported and filed in the office of the clerk of the court. The expense of the referees and stenographer is to be met by the State.

The referee is to prepare the decree, which may be modified by the court. The decree is to set forth "the name and post-office address of the person, corporation, or association entitled to the use of the water, the quantity of water in acre-feet or the flow of water in second-feet to be used, the purpose for which the water is to be used, the time during which the water is to be used each year, the name of the stream or other source from which the water is diverted, the place on the stream or other source where the water is diverted, the priority number of the right, the date of the right, and such other matter as will fully and completely define the right of said person, corporation, or association to the use of the water."

Appeal may be taken to the supreme court of the State, but must be taken within six months. If the decree is not appealed from, or within thirty days after the final decree in case of appeal, the clerk of the court is to issue to each party a certificate of his rights, which is to be recorded in the office of the county recorder. A duplicate is to be sent by the clerk to the State engineer, and by him filed in his office. This will provide a double record of all rights—one in the office of the county recorder and one in the office of the State engineer.

As was stated, there has been no adjudication under this law. But a hydrographic survey of the Weber River system has been begun by the engineer preparatory to an adjudication. The law providing for this is general in its terms, requiring the engineer to make complete hydrographic surveys and "construct maps which shall exhibit the essential facts relating to the supply, diversion, and use of the water. * * * He shall also collect such other facts as will, in his judgment, aid in ascertaining the existing rights to the use of water and in determining the volume of the surplus or unappropriated water, if any, of each of such streams or sources." The details are left to the engineer.

In this case the work is being done on an elaborate scale. The first step was to make an examination of each ditch to determine the proper place for putting in a measuring device, and the size and kind of device best suited to each ditch. Detail drawings and bills of material for each structure were then made. The device adopted is a flume with a removable trapezoidal weir plate. The weir plate is removed during high water and replaced in low water. It is also raised whenever it is necessary to clear out the sediment which has collected behind it. The engineer and his assistants also supervised the placing of the flumes, to insure its being properly done. As there are 1,175 ditches on this river system, this involved a great deal of work. The engineer reports that these devices have been put in in at least 90 per cent of the ditches.

After the weirs have been set readings are made at frequent intervals and recorded, so that at the end of a season the records of the engineer will show how much water has been used by each ditch throughout the season, when use began, and when it ceased. These records will give the court full information as to the use of water at the present time.

The location of canals and of the land irrigated is ascertained by careful instrumental survey, in which distances are determined by stadia and elevations by vertical angles. From these surveys three sets of maps are made, known as the unit maps, the diversion maps, and the division maps. A division map shows a large section of the stream system. Each unit map represents a single numbered section and shows all diverting ditches and laterals, the positions of all measuring devices, the boundaries of each individual farm, what portions of each farm are irrigated, the locations of orchards, buildings, towns, streets, roads, and other natural or cultural features. Contours are also shown. The diversion maps show each ditch system complete and give the same data. On the unit and ditch maps each farm is numbered. This farm number is recorded in a book called the "Register of rights," in which, opposite the farm number, is written the name of the owner of the water right for that farm. There is space for recording changes in ownership.

While making field surveys the engineer's assistants collect information as to the time of construction, the first use of water, and all subsequent changes. The facts collected regarding each ditch are recorded in a book called "Record of diversion No. ——." The book contains blanks for the facts required by law (see p. 63), there being a blank for the ditch as originally constructed and one for each subsequent change.

After the surveys of a ditch are completed and the information as to dates of original construction and enlargements have been brought together, a meeting of those interested is called, the facts collected are discussed, and the people come to an agreement as to what they will claim for their ditch. The records of diversions will be filed with the court when the matter comes before it.

The surveys of the Weber have not been completed. The engineer estimates that this survey will take six years and that the entire expense will be $80,000. The area irrigated is approximately 75,000 acres, making the expense slightly more than $1 per acre for the lands now irrigated. This is all borne by the State. This matter was fully discussed before the law was passed, and bankers and other large taxpayers said they were willing to bear their part of this expense for the sake of the general prosperity it would induce. When the matter comes before the court the fees of referees and stenographers are also to be borne by the State.

In cooperation with the Utah Agricultural Experiment Station soil surveys of the tract are also being made. The estimated cost of this is 1.25 cents per acre.

This system is much more elaborate than that adopted in any other State, and it remains to be seen whether it will be maintained in Utah. The law is general in its terms, and it is in the power of the engineer to simplify the procedure if he deems it advisable. One of the greatest drawbacks is the time consumed. If the surveys of a single stream are to occupy the time of the engineer and his assistants six years, it will take a great many years to adjudicate the rights to the streams of the State. This new law did not repeal the old law, under which in any water-right suit all parties claiming rights to the same source may be made parties to the action. It is quite likely that in the years that must elapse before the rights throughout the State are defined under the new law many will be defined in the old way. There is no provision for hydrographic surveys in such cases nor for the issuance of certificates by the court when a decree is rendered. It would seem that there might well be provision similar to that in Idaho, for the court to call on the engineer to make surveys and measurements, and by all means there should be provision for the issuance of certificates by the court. The numbering of these could be left to the engineer when they are filed with him for record.

ACQUIREMENT OF RIGHTS.

Supervision of the acquirement of rights to water was given to the State engineer in 1903. Before that there was provision for posting and filing notices, but nothing more. The new law provides that rights may be acquired under its provisions and not otherwise. The party wishing to acquire a right to water must apply to the engineer and receive a permit, and must, at the expiration of the time allowed, submit proof of completion, after which a certificate is issued stating what rights have been acquired.

The application must contain the same information as is required from a claimant whose rights are being adjudicated (see p. 63). Originally all classes were made on the same form, but there was a tendency for applicants to fill all blanks, whether they should be filled or not, producing a good deal of confusion. A form with the blanks for different uses all on one sheet, but under separate headings in large type, was next tried, but there was still a tendency to fill all blanks. Now separate forms are used for irrigation, power, and mining applications. In order to get their applications in proper shape and avoid the loss of time due to making corrections, many applicants come to the engineer's office and fill out their applications with the aid of the engineer or his assistants. No maps are required with the applications, but the place of diversion and the place of returning the water to the stream must be tied to a government corner or mineral monument if there is one within 6 miles. When an application is received, it is recorded at once if it is accompanied by the proper fees. If the fees are not paid, no record is made, but the applicant is notified and the application is indorsed as received on the date when the fees are paid and then recorded. It is then examined to see that it contains the required facts. If it does not, it is sent back for correction or additions. If it is not corrected as required, no further proceedings are had. When the application is in proper form, the engineer at once publishes at the expense of the applicant a notice of the application. This notice must be published in a newspaper having general circulation in the river system referred to for thirty days. In addition to the description of the proposed diversion, the published notice contains the statement that "all protests against the granting of said application, stating the reasons therefor, must be made by affidavit in duplicate and filed in this office within thirty days after the completion of the publication of this notice." The expense of publication has been from $7.50 to $18, depending on what paper it was published in. A good many applications have been dropped at this point because of the cost of advertising.

Although protests should be in the form of affidavits, informal protests are sometimes received and recognized in case formal protest is made within a reasonable time and accompanied by the proper fee. The law passed in 1903 provided for a hearing on a protested application, but when the engineer attempted to hold such a hearing it was prohibited by order of the court, on the ground that that provision of the law was unconstitutional, because it attempted to confer judicial power on the State engineer, and under this provision the engineer claimed the power to determine rights to water. The contention of the engineer was that the applicant had as yet no right to be determined and that the hearing was simply an inquiry to learn whether there was water in the source of supply to which the applicant might acquire a right. This case was decided against the engineer and that provision of the law has been repealed. Under present practice all protests are sent to the applicant, who has an opportunity to file an answer called a "rebuttal protest," and he is requested to make this in the form of an affidavit. In some cases the protestant has been allowed to answer again. After these formal papers are all in, the engineer sometimes talks the matter over with the parties informally before making his decision. Either party may appeal to the courts from the decision of the engineer. As passed in 1903, the law empowered the engineer to reject an application when there is no unappropriated water in the proposed source of supply or when the proposed use will conflict with existing rights or threatens to prove detrimental to the public interest. The engineer refused an application which he deemed detrimental to the public interests, and the case was appealed to the court, where the engineer was overruled. This clause of the law was repealed in 1905, but it is still the duty of the engineer to reject applications "where there is no unappropriated water in the proposed source of supply or where the proposed use will conflict with prior applications or with existing rights." This follows the Nebraska doctrine in making an approved application exclusive, since the law specifically mentions conflict with prior applications as cause for rejection. The engineer is also given authority to inquire into the financial ability of applicants and into their good faith, but there is no authority to reject an application on either of these grounds, as the engineer is required to approve all applications "made in proper form and which are not in conflict with prior applications or when the proposed use will not impair the value of existing rights."

In approving an application the engineer fixes the time at which the work must be completed, not exceeding five years from the date of approval, but he has authority to extend this time later, for good reasons. Work must be begun within six months, but there is no provision for determining whether this is done. In making final proof the applicant swears to this, however.

Final proof consists in statements by the appropriator sworn to by himself and two disinterested witnesses, and a map, profile, and drawings made on tracing linen showing:

> The location with reference to the United States land surveys; the nature and extent of the completed works; the natural stream or other source from which and the place where the water is diverted; the places and manner of crossing or connecting with other works or streams; the ground and grade lines, cross sections, and dimensions of the various forms of the diverting channel; the character of the materials moved and used in construction; the several appliances employed to divert, measure, and regulate the water; the character of all structures which cross, support, or constitute the diverting channel or any part of it and such other matter as will fully and correctly delineate the work done and conform to the general rules and regulations of the State engineer's office. The map, profile, and drawings shall each be certified, under oath, by the engineer who has made the same and by the applicant whose works they represent, said certificates to be substantially of such form as the State engineer shall by general rule prescribe. No certificates of appropriation shall be issued by the State engineer before the proof of appropriation shall have been made in the manner hereinabove described and any person who shall refuse or neglect to make such proof shall be guilty of a misdemeanor.

The rules of the engineer require that the maps shall be in duplicate on tracing linen, on sheets 24 by 30 inches, on a scale of 400 feet to an inch, and if the whole can not be shown on one sheet more than one must be used. Profiles must show the ground line of the diverting channel in India ink, grade line of diverting channel in red ink, cross sections of the various forms of the channel and the dimensions thereof. Drawings must show the details of the diverting dam; details of head gate, measuring device, crossings, flumes, trestles, bridges, and other structures, and the character of materials to be used in structures. All of these must be certified to by the engineer making them. These maps and drawings were originally required within six months after the approval of the application, but the engineer recommended the change to the present plan, because of the expense to the applicant and because some changes as construction proceeds are unavoidable, and wherever changes are made the maps and drawings made in advance do not show the completed works correctly, and what is wanted is a record of the works as built.

There is no provision for inspection of works by the engineer, although he sometimes does inspect them. The engineer does not favor compulsory examination by himself or an assistant, for the reason that this would entail an unwarranted expense for small works in remote parts of the State. This same reason has been urged against examination in other States where it is required.

Upon receiving satisfactory proof of the completion of works in accordance with an approved application, the engineer issues to the appropriator a certificate setting forth substantially the same facts as the certificate issued by the court after an adjudication (see p. 65). The certificates are issued in duplicate, one is filed in the office of the State engineer and one delivered to the appropriator, who must, within thirty days, have it recorded in the office of the county clerk of the county in which the diversion is made. Certificates issued by the court are to be in one series marked "A," and those issued by the engineer in another series marked "B."

The distinctive feature of the Utah certificates is that they define the part of each year during which the water may be used. Usually applicants state the entire year as the period during which they will use the water, but the engineer has refused to allow such applications unless it is shown that the water is to be actually used throughout the year. This limiting of rights to a part of the year has always been a part of the Utah system of water rights, and its absence in other States is coming to be one of the most serious defects in those systems. Up to September, 1905, seven certificates had been issued by the State engineer.

The total expense in fees of securing a right under the Utah law is as follows:

Fee for filing application	$2.50
Fees for approving and recording completed application	2.50
Advertising	[a] 10.00
Fee for examining maps, etc., with final proof	5.00
Fee for certificate of appropriation	1.00
Total	21.00

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[a] See p. 68.

DISTRIBUTION OF WATER.

Officials to distribute water are provided for by the law of 1903, but have not been appointed because rights have not been defined, and there is therefore no basis for distribution. A former law provided for the appointment of water commissioners by the county commissioners, and a few were appointed. The new law provides that these commissioners shall serve until superseded by officials appointed under the new law.

The engineer is to divide the State into divisions and these into districts from time to time as necessity arises. For each division there is to be a superintendent appointed by the engineer with the consent of the governor, who shall hold office during the pleasure of the engineer. For each district there is to be a supervisor appointed by the county commissioners of the county in which he serves, who is to hold office during the pleasure of the county commissioners. The supervisors are to be under the direction of the superintendents, who are, in turn, directly under the supervision of the engineer. This system brings the distribution of water directly under the control of the State engineer, and any one deeming himself injured by any act of either a superintendent or a supervisor may appeal to the engineer. The compensation of each superintendent is to be fixed by the engineer according to the work required of him; that of the supervisors is to be $3 per day, to be paid by the county where the work is done.

Interference with a person legally apportioning water is a misdemeanor. Ditch owners are to maintain head gates and measuring devices. Plans are to be approved by the engineer, and he is to furnish specifications and bills of materials if, in his opinion, this will encourage the putting in of the structures. Failure to put in structures within thirty days after requested to do so by the engineer is a misdemeanor, but no punishment is specified. The engineer has not pushed this matter, preferring to get along with current meter measurements and the existing headworks until surveys for adjudication are made, when the structures will be put in.

MISCELLANEOUS.

Water rights pass with the transfer of land if no mention is made of the matter, but they may be reserved or may be transferred separately. Under the law of 1905 transfers must be reported to the State engineer; and if the place of diversion is changed, a map showing the change must be filed with the engineer. Failure to make such report to the engineer is a misdemeanor.

Any person wishing to build a dam more than 5 feet high in the course of a running stream, or any dam to hold water more than 10 feet high, must submit plans, drawings, and specifications to the engineer for his approval, and the engineer has authority to keep an inspector on any dam during construction to see that it is built in accordance with the approved plans and specifications and may require any changes deemed necessary. Beginning construction before the approval of plans and specifications by the engineer, or proceeding with the work in the absence of the inspector, or failure to comply with any requirements of the engineer is a misdemeanor.

Anyone living in the vicinity of any dam may request the engineer to examine it to determine its safety. The engineer may require a deposit to cover the expense of examination. This is to be returned if the request was justified by the condition of the dam and the expense collected from the owner. There is no provision for forcing the payment if the owner refuses.

The engineer has authority to inspect any ditch or diverting works and may order any additions or alterations which he considers necessary for the security of the works, the safety of persons, or the protection of property. Failure to comply with the requirements of the engineer is a misdemeanor.

FEES.

The fees collected by the State engineer are turned over to the State treasurer. They are as follows:

For examining and approving plans and specifications for any dam, $1 for each and every foot in height of the dam to be built; and if necessary to inspect the site where the dam is to be built, an additional charge of $10 per day and expenses shall be made.

For inspecting any diverting works, by request, $10 per day and expenses.

For examining and filing application to appropriate water, each, $2.50.

For examining map, profile, and drawings that are part of the proof of appropriation, $5.

For approving and recording completed applications, $2.50.

For issuing certificates of appropriation, each, $1.

For examining and filing notices of protest, each, $2.50.

For filing any other paper, $1.

For certified copy of any paper, per folio, 20 cents.

For blueprint copy of any map, profile, or drawing, per square foot, 10 cents.

For each certificate to copy of paper, drawing, or map, 50 cents; provided that the provisions of section 67 shall not apply to works prosecuted under the supervision of the United States Reclamation Service.

The fees collected during the year 1903–4 were as follows:

Fees received 1903–4.

For filing applications to appropriate water	$602.50
For filing maps, profiles, and drawings	445.00
For recording applications	65.00
For issuing certificates	23.00
For filing notices of protest	192.50
For examining and approving plans, etc	215.00
For withdrawing protests	2.00
For filing notice of change of diversion	1.00
For certified copies	29.60

For making blueprints	$32.90
For filing applications to have time extended	15.00
For copying records	15.00
Total	1,638.50

RECORDS OF ENGINEER'S OFFICE.

When an application is received it is recorded as received, even if it is to be returned for corrections. All corrections are then put on this record in red ink. The record book is indexed by the names of the applicants and also by names of streams, the index showing, also, the file numbers and the dates of recording. There is also a card index of names of applicants, the cards containing file numbers of applications and index numbers of maps and drawings. Maps and drawings are numbered on the decimal system.

NEVADA.

The office of State engineer in Nevada was created in 1903. In 1901 there was created a State board of irrigation, composed of the governor, the surveyor-general, and the attorney-general. In 1905 the State engineer was made a member of this board also. The first duty assigned to the State engineer was to define existing rights to water in the State of Nevada. To provide a basis for this defining of rights, all county recorders were required to furnish the engineer with copies of the claims to water rights filed in their respective counties. In 1889 a law was passed requiring all parties having claims to water from the streams of the State to file their claims with the county recorders. This law was repealed four years later; but before this repeal the owners of most of the existing rights had filed claims with the county recorders, and most of those who have acquired rights since that time have done so. Since the passage of the new law all but three counties in the State have supplied the engineer with copies of the claims. These claims furnish the engineer with a basis for beginning his adjudications.

DEFINING RIGHTS.

The engineer is required to examine the streams and the works diverting water therefrom, make measurements of the streams unless sufficient measurements are already in existence, determine the carrying capacity of the ditches and canals, examine the irrigated lands, and make approximate measurements of these lands, and make maps or plats on a scale of not less than 1 inch to the mile, showing the courses of the streams, locations of the ditches, and the legal subdivisions of land which have been irrigated or which are susceptible of irrigation from the ditches already built. In practice the engineer has made no such measurements, except in cooperation with the United States Geological Survey. The Survey is making maps showing the location of all ditches and all irrigated lands, with the names of the owners, contour lines, and, more recently, farm buildings. Such maps have been made for the Carson, Truckee, and Walker rivers, and one is now being made for the Humboldt River. The State is to pay not to exceed one-tenth of the total cost of these surveys. Having these maps, the engineer traces new maps of the tracts belonging to each farmer. These small maps are taken to the farmers, and the engineer goes over the ground to assure the farmer that the map is correct and get his signature to it as correct. When the maps have been signed in this way, the areas of irrigated land are measured with a planimeter. After these measurements are made, the farmer is again visited and testimony is taken as to when each piece of land was first irrigated. These statements are then compared with the claims previously filed, and if there is a disagreement the matter is gone over with the owner and with his neighbors and an attempt is made to explain the difference and make the new claim correct. Dates of all extensions and enlargements of ditches are secured in the same way. All of this taking of testimony is done by personal visits to the landowners rather than in any formal hearing. As much of the land has changed hands since it was first irrigated, the owners are not always conversant with the facts as to early use of water, and in such cases the older settlers who are still residing in the neighborhood, or sometimes those who have moved away, are called in to give testimony as to the facts. In some cases early settlers are induced to return for this particular purpose, and in other cases their testimony is secured by deposition or informal communications. The expense for this collecting of testimony is paid by the owners of the land.

All of the material collected in this way is finally summarized by the engineer and put in such shape that it can be sworn to as depositions in case of contest. The compilation of the testimony made by the engineer is printed in pamphlet form, a copy being sent to each claimant and to his attorney, if he has one, in order that all may have notice of the claims of others as well as of their own claims. Such a pamphlet was issued for the Carson River.

The claims make no mention of the quantities of water used, but give merely the acreages by legal subdivisions and the dates when they were first irrigated. No contests arose in the adjudication of the Carson, but in case they had arisen each claimant would have been required to protect his own right. The engineer would not have been responsible for this. From these claims the State engineer made up his list of rights on the Carson, the only expense to the claimants being the notary fees. Certificates were issued to the claimants, stating what rights they were found to have. The law requires that these shall be recorded in the office of the engineer, and that one copy shall be sent to the claimant and one copy to the county recorder. The law provides for the payment of the filing fees by the State. Most of the parties claiming water to the Carson had no attorneys, and the entire expense for defining rights and securing certificates was limited to the notary fees for their sworn statements.

The decisions of the engineer may be appealed from to the courts within two years, but no such appeals have been made from the Carson decree, the only one yet made. The time for appeal has not yet expired.

The rights to Walker River are now being determined in the same way. In this case it is proposed by the engineer to prepare findings, but instead of issuing certificates on his own authority turn over his findings to the court having jurisdiction of that stream and have his decree issued as a decree of the court. There has been considerable doubt as to the constitutionality of the law providing for the defining of rights by the engineer, and the course proposed for Walker River is to avoid any danger of having the certificates declared void after they have been issued by the engineer.

ACQUIREMENT OF RIGHTS.

Up to 1905 parties wishing to acquire rights to water were required to post and file notices stating what they claimed, and no further action was ever taken on these claims. In 1905 a law was passed requiring that parties wishing to appropriate water apply to the State engineer for permission to do so. These applications are to give the name and post-office address of the applicants, the source from which the water is to be taken, the amount to be taken, the location of the proposed works, the time required for their completion, including the time required for the application of the water to a beneficial use, and if the water is to be used for irrigation a description of the land to be irrigated. These applications are to be made on forms furnished by the engineer without cost to the applicant. He may return any application for correction, but all applications if properly corrected take priority in the order of their original receipt by the State engineer. When properly filed with the State engineer, the engineer is to publish in some newspaper having a general circulation within the boundaries of the river system a notice of the application, showing by whom made, the quantity of water sought to be appropriated, the stream from which the appropriation is to be made, and at what point on the stream, the use for which it is to be appropriated, and by what means. This notice is to be published once a week for four weeks. At any time within thirty days after the completion of the publication any party interested may file with the State engineer a written protest against the granting of the application, stating the reasons therefor.

The engineer may, in his discretion, hear evidence in support of or against any application and shall then take such action thereon as he deems proper and just. Such hearings have been decided against in Utah as an exercise of judicial power by the engineer. (See p. 68.)

If there is unappropriated water in the source of supply and if appropriation is not detrimental to the public welfare, the engineer is required to approve the application. The present engineer interprets the clause allowing him to reject an application because detrimental to the public welfare as giving him but little power. He deems it the duty of the engineer to accept the applications in the order of their receipt if there is unappropriated water and the new appropriation is for a lawful use. Anyone dissatisfied with the action of the engineer may appeal to the courts within sixty days after the decision of the engineer, but until the engineer's decision is overruled by the court the party is not allowed to proceed with the construction. Within six months after an application is approved by the engineer the applicant must file a map on a scale of not less than 2 inches to the mile, showing the location of the works, source of appropriation, and, if for irrigation, the land to which the water is to be applied. On submission to the engineer of satisfactory proof that works have been built in accordance with the approved application and the water applied to the beneficial use intended, there is issued to the applicant a certificate setting forth the name of the appropriator, the date, source, purpose, and amount of the appropriation, and, if for irrigation, a description of the land to be irrigated. These certificates are to be recorded within thirty days in the county in which the point of diversion is located and also in the county where the water is to be used in books specially kept for that purpose, the fee for this recording being $1, to be paid by the party in whose favor the certificate is issued. Between May 1, 1905, when this law went into effect, and September 5, 1905, twelve applications had been made, nearly all of these being for large and important works. But one of these had been approved September 1. The others had not yet been acted upon. The rules for submitting final proof have not yet been formulated, as there is not yet any occasion for their use.

The usual expense for publishing the notice of an application is from $7.50 to $10 for the four weeks required. After this publication, if no objection is made, the applications are granted.

DISTRIBUTION OF WATER.

For the distribution of water the State board of irrigation is given power to divide the State into such districts as are necessary and to appoint water commissioners for these districts. The engineer, however, has general supervision of the distribution. On the Carson River, the only one adjudicated thus far, the engineer has divided the rights into groups by dates. The United States Geological Survey maintains gauging stations on the stream, and the engineer receives weekly records of the discharge of the river. From these he determines what rights can be supplied and distributes the water accordingly. For instance, he decides that the rights antedating 1875 can be supplied at a particular time. Among the holders of rights prior to that date priorities are not recognized, but the water is distributed to them in the manner in which, in the opinion of the engineer, it can be made to do the most good. During the season of 1905 an attempt was made to maintain all perennial crops and bring to maturity the second crop of alfalfa throughout the valley. The engineer estimates that during the season of 1905 this method of distribution saved the Carson Valley $200,000 over a strict enforcement of priorities. It is probable that any holder of an early right might have succeeded in securing his full supply regardless of the sufferings of his neighbors had he gone into court, but with one exception no objection was made to the distribution made by the engineer. The party objecting attacked a water commissioner and was fined for resisting an officer.

The water commissioners receive $4 per day, which is paid by the county. It is estimated that the county of Douglas will pay during the season of 1905 $600 for distributing water to about 25,000 acres, or 2.4 cents per acre.

MISCELLANEOUS.

Parties entitled to water are required to make application to the State engineer before any transfer may be made, but in practice farmers are allowed to use the water to which they are entitled on lands other than those in connection with which the rights were acquired if others are not injured by the change. That is, if a farmer prefers to use his water on new land and let the old land lie fallow, he is allowed to do so. This is done upon the theory that the water would be used on the old land if the farmer was not allowed to use it on the new land, and it makes no difference to the holders of the other rights what land the water is used on.

It will be seen from this description of the work of the engineer that he has maintained a very close personal relation with the water users and that his work has been very largely that of a friend and adviser rather than an arbitrary official. This system has apparently worked very satisfactorily in the limited field in which it has been tried. In the nature of things the engineer can not come into such close personal relations with the people of the whole State as the irrigated area is enlarged. It is doubtful, therefore, whether the law has thus far had a fair test.

MONTANA.

While Montana has a State engineer, he has nothing to do with the control of the water supply of the State. The office was created in 1903 in connection with the acceptance of the Carey Act. The State has a Carey land act board, composed of the State engineer, the secretary of state, and the State examiner, the State engineer being chairman. His duties are to examine State lands to determine their irrigability, examine and measure the streams of the State, and serve on the State board of health. In addition to the above, all applications to the Carey land act board to reclaim land under that law are submitted to the State engineer, and he is required to examine the land applied for and determine the feasibility of its reclamation. If he approves the project, he is to cause the reservation to be made and notify the applicants of his action in the matter. The law further provides that anyone wishing a reconnaissance for a proposed Carey Act project may apply to the board, depositing the money to cover the expense, and have the examination made by the State engineer. It is further provided that parties wishing to reclaim land under the Carey Act may organize cooperative associations for the purpose of reclaiming by their own labor lands subject to reservation. For such associations the State engineer is required to investigate the proposed project, and if he finds it feasible he is to prepare the maps and data required for having the land segregated under the Carey Act and prepare the engineering plans necessary for the reclamation of the land and exercise general supervision over the carrying out of the plans. No applications for work under this provision have been made.

The Carey land act board succeeded the arid land grant commission, which was created by the original law accepting the conditions of the Carey Act. The commission has entered into contracts for the reclamation and settlement of three tracts. Work under all these was incomplete at the time of the creation of the new board, and the first work of the engineer was to examine into the condition of these three projects. One of them, at Billings, has been completed, examined by the engineer, and approved by him. The other two have been examined by him and found in very unsatisfactory condition. The board is attempting to straighten out their affairs so that work can proceed and the projects be carried out.

Aside from the examination of these three Carey Act projects, the work of the engineer's office has been confined almost exclusively to examining State lands to determine their irrigability. In some instances the work has included the making of plans for works to reclaim the lands, but at present there is no authority to reclaim any land. The plans are being made in the hope that the State will be able by showing the feasibility of plans to induce some one to take up the construction of the works to reclaim the lands.

DEFINING RIGHTS.

In Montana rights are adjudicated by the courts, on testimony of interested parties, no provision being made for hydrographic surveys or for a special form of procedure. Any interested party desiring an adjudication may apply to the court and make all parties taking water from the same source parties to the action. Rights throughout the State are not very generally adjudicated.

ACQUIREMENT OF RIGHTS.

Any person wishing to appropriate water must post a notice stating what is claimed and file a copy of the claim with the county clerk of the county in which diversion is to be made, stating the usual facts as to place, quantity, use, etc., and must prosecute work with reasonable diligence. There is no inspection or record to show whether recorded plans have been carried out, but under a law passed in 1905 anyone having completed the construction of irrigation works may, after publishing notice, have his ditch and the lands irrigated or proposed to be irrigated surveyed by a competent surveyor, and file a sworn copy of the map made from this survey with the clerk and recorder of the county. Such a map is made prima facie evidence of the facts shown. F. H. Ray's report to the governor shows that in 1902 there were 26,646 recorded claims to water from Montana streams, with no records to show what rights have been acquired under these filings. Very many have been abandoned, but no one knows how many. Since construction of works and use of water are necessary to the acquirement of a right, the records are of no value, except that where a claimant can show a recorded claim his right may be made to date back to the time of filing. They are thus a menace to other rights, because this adds another element of uncertainty as to when a right will be held to have been acquired when an adjudication takes place. Such filings are being made by practically all appropriators at present.

DISTRIBUTION OF WATER.

There is no provision in Montana for any State participation in the distribution of water. Where rights have been adjudicated, on request of the owners of at least one-fourth of the rights affected by the decree, the court appoints a water commissioner, whose duty it is to distribute the water decreed. Parties not included in a decree can not be interfered with by the commissioner. Each commissioner is to keep a daily record of the water delivered to each user, and submit a summarized statement of this to the court appointing him at the close of the season, together with the bill for his services. The court then assesses the expense against the various parties in proportion to the quantities of water delivered to them by the commissioner. Under this law a number of commissioners have been appointed, but more than half of the counties report that no commissioners have been appointed. An effort was made to secure reports of commissioners to ascertain the cost of distributing water, and a few were received. The commissioner for Tenmile Creek, which supplies the city of Helena and a considerable area of farm land finished his work in 1905, on July 26, when the stream became so low that the first right—that of the city of Helena—took all the water. He submitted to the court his report showing the quantities of water received by each of the thirty-two parties having decreed rights, with his bill for $267.85 for services rendered. The largest sum was paid by the city water company, $75.80, while the sum assessed against one party was but 10 cents for the season, a number paying less than $1. This is a small stream, and water was unusually low in 1905, but it illustrates the system.

A commissioner was also appointed for Prickly Pear Creek, in the same county, August 2, 1903, the decree defining the rights to that stream being issued at that time. He is to receive, according to the order of the court, $100 per month. His report was not secured.

The following table shows the total volume of water distributed by seven other commissioners and the cost of their services per twenty-four hour inch. The commissioners kept no records of the acreages served, and the cost per acre can not be given:

Cost of distributing water in Montana.

Stream.	County.	Water delivered.	Cost per 24-hour inch.
		24-hour inch.	*Cents.*
Dempsey Creek	Deer Lodge	115,617	0.19
Race Track Creek	do	283,621	.11
Mill Creek	Ravalli	16,330	.66
Horse Creek	do	5,492	1.31
Fred Burr	do	14,301	.72
Mill Creek No. 2	do	1,393	2.75
Burnt Fork Creek	do	277,322	.18

Any interested party dissatisfied with the action of a water commissioner may file a complaint with the court and have a hearing. No records of such complaints were found.

The provisions of this law have been extended to the distribution of water under ditches. On application by owners of 51 per cent of rights the court is to appoint a commissioner for a ditch. No records of such appointments were found.

NORTH DAKOTA.

In 1905 North Dakota adopted a code of water laws providing for the adjudication of existing rights and the complete public control of the water supply in the future. The office of State engineer is created, and the engineer is given "general supervision of the waters of the State and of the measurement and appropriation thereof."

The previous law of North Dakota provided for posting and filing notices, as did the laws of other States, and the State engineer has secured from the county officers copies of all such notices. The records show nothing as to what was done under these notices, but the engineer has examined the locations covered by a number of them and found that nothing had been done under those particular ones. The early notices seem, therefore, to represent very few, if any, existing rights. This is shown also by the census of 1902, which gave the area irrigated in North Dakota as about 10,000 acres. This includes considerable areas which are flooded by natural overflow. The area which can be called irrigated is much smaller. The present law, therefore, goes into effect with very few undefined rights to stand in the way of the engineer in assuming control of the waters of the State. The engineer is empowered to make all necessary general rules and regulations to carry into effect the duties devolving upon his office.

DEFINING RIGHTS.

The engineer is to make hydrographic surveys of the streams of the State, beginning with those most used for irrigation, "obtaining and recording all available data for the determination, development, and adjudication of the water supply of the State." When the survey of any stream is finished, the engineer is to deliver a copy of the maps made to the attorney-general of the State, together with all data necessary to the determination of the rights to the stream. The attorney-general is to intervene on behalf of the State, if advised to do so by the engineer, and in any suit brought hereafter the court is to call on the engineer to make hydrographic surveys.

When a decree is rendered, two certified copies are to be made, one to be filed in the office of the State engineer and one in the office of the water commissioner of the division in which the stream is situated.

The costs of the hydrographic surveys are to be assessed against the parties to the adjudication, but $2,000 is appropriated for advancing these costs. This is to be a permanent revolving fund. No adjudications have been begun and probably will not be for some time. A few streams in the northwestern part of the State are beginning to be over-appropriated, and surveys and adjudications may be made there in a few years.

As no adjudications are under way, the engineer has not determined what he will include in "all data necessary to the determination of the rights."

ACQUIREMENT OF RIGHTS.

Any person, association, or corporation wishing to appropriate water must make application to the State engineer for a permit to do so, in the form prescribed by the State engineer, giving "the data necessary for the proper description and limitation of the right applied for, as also the amount of water applied for and the periods of annual use, together with such information, maps, field notes, plans, and specifications as may be necessary to show the method and practicability of the construction and the ability of the applicant to complete the same." The engineer may send them back for correction and further information. The applicant must publish notice of his application, giving the essential facts as to the proposed appropriation, and submit proof of publication. Upon receipt of proof of publication, the engineer is to determine from the testimony of the interested parties, such surveys as are available, and the records of his office, whether there is unappropriated water in the stream. If there is, and the approval of the application is not contrary to the public interests, the engineer is to approve it. Any applicant dissatisfied with the action of the engineer may appeal to the district court of the county in which the proposed place of diversion or storage is situated. The approved application must state the time required to complete works, and if after approval of application one-fifth of work is not done in one-half of the time allowed, the engineer may accept and approve an application from some one else for same water, and the original applicant will thus lose his priority. But the engineer may extend the time allowed the original applicant to such an extent as construction has been prevented by the operation of law.

On the date set for the completion of the works or sooner, on receipt of request of the appropriator, the engineer is to cause the work to be inspected. If it is not satisfactorily completed the engineer may require changes, granting not to exceed six months for this. If it is satisfactorily completed, the engineer is to issue a certificate "setting forth the actual capacity of the works, and making such limitations upon the right as shall be warranted by the condition of the works, but in no manner extending the rights described in the permit."

Upon the date set for the application of the water to a beneficial use the engineer is to examine the works and issue a license to appropriate water to the extent and under the conditions of the actual application thereof to a beneficial use, but in no manner extending the rights described in the permit. The engineer may extend the time for completing works not to exceed three years, and for applying water not to exceed two years, "but only on account of physical or engineering difficulties which could not have been reasonably anticipated, or by operation of law beyond the power of applicant to avoid."

Only one or two applications have been made thus far and these have passed through only the preliminary stages. The engineer has prepared blank forms of applications, proofs of publication, etc., but it is not expected that any works will come to the stage where proofs of completion or of the application of water to a beneficial use will be submitted for some time, and forms for such proofs and for the license have not been prepared.

DISTRIBUTION OF WATER.

The State is divided into four divisions, and for each division the governor may appoint a water commissioner, who is to have supervision of the distribution of the water within his division according to the licenses issued by the State engineer or the adjudications made by the courts. No water commissioners have yet been appointed, as there is nothing for them to do. The four water commissioners and the State engineer constitute the board of water commissioners, which has "general supervision of the apportionment of the waters of the State."

Divisions may be divided into districts, as the necessity arises, and water masters may be appointed by the water commissioner on approval by the State engineer. Water commissioners are to have immediate charge of distribution of water in their respective districts, and may appoint assistants. Water commissioners are to receive $10 per day, not to exceed two hundred days in one year, paid by the State. Water masters are to receive $4 per day, to be paid by the counties, but collected by them from the ditch owners, in proportion to the work done "as to each ditch and water right." The engineer receives a salary of $2,500 per year.

FEES.

The fees collected by the engineer are turned into the State treasury. The fees allowed are as follows:

Examining application with maps, etc., $5; recording permit, certificate, etc., $1 for first 100 words and 15 cents for each additional 100 words; filing any other paper, $1; issuing certificates of construction or license, $1 each; making copy of any document, 15 cents for each 100 words; blueprints, 10 cents per square foot; copy of drawings, cost of making; certifying to copies, $1.

For examining and approving in connection with water right applications, plans, and specifications for any dam, not exceeding 10 feet in extreme height from the foundation, $10; for a dam higher than 10 feet and not exceeding 30 feet, $20; for a dam higher than 30 feet and not exceeding 50 feet, $30; for a dam higher than 50 feet, $50; or for a canal, or other water conduit of an estimated capacity exceeding 50 and not more than 100 cubic feet per second, $20; for an estimated capacity exceeding 100 cubic feet per second, $30.

For inspecting dam sites and construction work when required by law, or when necessary in the judgment of the State engineer, $10 per day and actual and necessary traveling expenses. The fees for any inspection deemed necessary by the State engineer and not paid on demand shall be a lien on any land or other property of the owner of the works, and may be recovered by the State engineer in any court of competent jurisdiction.

Rating ditches or inspecting plans and specifications of works for the diversion, storage, and carriage of water, at the request of private parties, not in connection with an application for right to appropriate water, actual cost and expenses; and the State engineer shall attach his approval to such plans and specifications if found satisfactory.

The work of the engineer thus far has been very largely one of exploration to determine what development by irrigation is possible, and to become acquainted with conditions throughout the State. He is working in cooperation with the Irrigation and Drainage Investigations of the United States Department of Agriculture in making surveys for drainage works in the Red River Valley. He is cooperating with the Forest Service of the United States Department of Agriculture in determining the relation of the forests of the State to the water supply of streams; with the Bureau of Plant Industry in experimenting with various kinds of willows, as protection to the banks of streams, helping to make their channels permanent; and with the Reclamation Service of the Interior Department, in determining the feasibility of projects to be undertaken under the provisions of the reclamation law.

The irrigation law provides that the engineer cooperate with county commissioners in the engineering work required to lay out and construct drains. This is being done in cooperation between the Irrigation and Drainage Investigations of the United States Department of Agriculture, the State engineer, and the counties interested.

The engineer is also charged with fixing rates for the sale of water.

OREGON.

The office of the State engineer was created in 1905, but he was given little control of the waters of the State, his duties being confined almost entirely to making hydrographic and topographic surveys in the State. There was appropriated $2,500 for hydrographic surveys and $2,500 for topographic surveys, both contingent upon the setting apart of equal sums for similar work by the General Government. The United States Geological Survey has supplied these funds, and the State engineer is the resident hydrographer of the Survey. Gaugings of the various streams of the State and topographic surveys of the irrigable lands are being made under this provision.

DEFINING RIGHTS.

Whenever the Reclamation Service wishes to begin the building of works on any stream of the State the Secretary of the Interior may notify the State engineer, and he must then make surveys of the stream and the ditches taking water from it and the land irrigated. When these surveys are completed, the results are to be filed with the attorney-general of the State, who, at the request of the Secretary of the Interior, is to bring suit on behalf of the State for the determination of water rights on the stream. The validity of this provision has not been tested. In view of the fact that the provision for the beginning of adjudications by State officials has been overruled in

Idaho (see p. 50), it is doubtful whether it will stand in Oregon. There is no claim that the water belongs to the State on which to base the proceeding.

Whenever any suit for the determination of water rights is brought and the State is a party to the suit, the court may call on the State engineer to make surveys similar to those referred to above. These surveys are to include complete hydrographic surveys of the entire stream system to determine the amount of water used by each claimant, the character of the land watered, and the duty of water for each tract, and the collection of all data necessary for the adjudication of the rights involved.

Such a suit has been begun on the Walla Walla River at Pendleton. No provision is made by law for paying expenses of the surveys to be made by the State engineer, his interpretation of the law being that the $2,500 appropriated for hydrographic surveys can not be used for this purpose, but must be devoted to general hydrographic surveys. The cost of surveys made in connection with suits is to be taxed against the parties, but the parties in the Walla Walla suit have made up a fund to pay for the surveys. The engineer has established stations to obtain complete records of stream and canal flow, is surveying and mapping all the ditches and irrigated lands, showing on his maps the character of the soil and character of the crops. He is required to make an estimate of the duty of water for each tract, and the surveys will contain the information on which he must base his estimates of duty. The law requires that the engineer shall "gather all data necessary for the adjudication of all rights involved." This he has interpreted to mean simply the information which can be secured by the making of surveys, but does not include any taking of testimony as to dates of construction of works and the use of water.

The suit on the Walla Walla just referred to is the only one which has been brought to which the State has been made a party. It will be noticed that this provision for surveys by the engineer applies only to actions to which the State is a party. In the Walla Walla case the State is made a party on the following grounds:

> That the State of Oregon owns lands on the tributaries of the Walla Walla River, holds mortgages on lands situated upon said river, and claims and asserts an interest in all surplus waters of said stream, and the right to control the same, during seasons of the year when there may be a surplus in said streams, which right is asserted under and by virtue of an act of the legislative assembly of the State of Oregon, approved and filed in the office of the secretary of state February 22, 1905, and for that reason is made a defendant herein.

There is no provision for the beginning of an adjudication by the State on its own motion.

ACQUIREMENT OF RIGHTS.

Parties wishing to acquire rights to the streams of Oregon hereafter must file copies of their claims with the State engineer, but he is required simply to make a record of these filings. About fifteen such filings have been made since the law went into effect. Whenever the Reclamation Service wishes to investigate the feasibility of using the water of any streams in Oregon it is to file notice of this fact with the State engineer, after which no adverse rights to water filed on by the Reclamation Service can be acquired during a period of three years, at the end of which time the Reclamation Service must file plans for the use of the water or it is again open to appropriation. With these filings, as with those made by private parties, the engineer has nothing to do but record them. The Reclamation Service is also to file with the engineer releases of water previously filed on in case its projects are abandoned.

The engineer has nothing to do with the distribution of water. The constitution of the State gives the legislature the right to enact laws providing for this, but the legislature has as yet made no provision for it. It is proposed to have the sheriff enforce the decree on the Walla Walla when it is made. The stream, so far as it lies in Oregon, is entirely within Umatilla County, and therefore no complications would arise from having the water distributed by the sheriff. The stream, however, flows into Washington, and complications with the people in the latter State might arise.

SOUTH DAKOTA.

The office of State engineer of irrigation was created in South Dakota in 1890. The duties of the office were to make general investigations of the artesian supply in the State and confer with manufacturers of well-drilling machinery and transportation companies, with a view to securing such machinery at the least possible cost. A later law provided for the location of artesian wells by the engineer on application of the residents of any township and for inspection of the completed wells by the engineer. The office was abolished in 1897 and provision made for an instructor in the State agricultural college, who should perform the duties of the engineer without expense to the State.

The matter stood in this way until 1905, when a general law was passed creating the office of State engineer and providing for the adjudication of existing rights, acquirements of new rights according to the Wyoming system, and for the distribution of water by State officials. Water from all sources not navigable is declared to be the property of the public and subject to appropriation for beneficial use. The engineer is to be appointed by the governor and confirmed by the senate, to hold office for six years and receive a salary of $2,000 per year. "He is to have the general supervision of the waters of the State and of the measurements and appropriation thereof, including the duties of locating surveys and making estimates of the cost of drainage canals and ditches within the State to carry off the surplus waters caused by the overflow of rivers, or otherwise preventing malarial diseases and damage to growing crops." However, no appropriation was made for the carrying out of the provisions of the law, and it has therefore been inoperative.[a]

DEFINING RIGHTS.

The State engineer is to make hydrographic surveys of each source of water supply in the State and collect and record all available data for the determination, development, and adjudication of the water supply of the State. Upon the completion of the hydrographic survey of any stream system he is to deliver copies of all data necessary for determination of the rights to the use of the waters from that system to the attorney-general of the State, who shall, within sixty days, bring suit for the determination of all rights to the use of the stream. However, if suit has been begun by private parties he need not bring another action, but shall intervene in such suit if notified by the engineer to do so.

In any suit for the determination of water rights, all who claim rights to the same source may be made parties, and the court is to call upon the State engineer to furnish complete hydrographic surveys and obtain all data necessary to the determination of the rights. The costs of the suit, including all work done by the State engineer, are to be charged to the parties in proportion to the amounts of water allotted to them. For the purpose of meeting these expenses an appropriation of $500 was made, to be returned to the State treasury when collected from the parties. Upon the completion of an adjudication the clerk of the court is to make two certified copies of the decree, one to be filed in the office of the State engineer and the other in the office of the water commissioner in the water division in which the stream is situated. The decrees shall in every case declare the priority, amount, purpose, place of use, and if for irrigation the specific tracts of land to which the rights shall be appurtenant, together with such other conditions as may be deemed necessary to define the right and its priority.

ACQUIREMENT OF RIGHTS.

Any party hereafter wishing to acquire a right to use water must make application to the State engineer for a permit, giving all the data necessary for the proper description and limitations of the rights applied for, together with such maps, plans, and specifications as are necessary to show the method and practicability of the construction and the ability of the applicant to complete the same. These maps, plans, and specifications are to be filed in duplicate, one copy to be retained in the office of State engineer and the other returned to the applicant. The applications may be returned for corrections or additions if defective in form or unsatisfactory as to the plan. Notice of application must be published at the expense of the applicant, and interested parties may be heard for or against the granting of the application. The engineer may reject applications if there is no unappropriated water in the source of supply, or if, in his opinion, their approval would be contrary to public interests; but any applicant may appeal from this decision to the court.

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[a] Since this was written an engineer has been appointed. He has prepared forms for applications for permits, and is making a general reconnaissance of the State.

An approved application becomes a permit, and in his approval the engineer must state the time within which the construction shall be completed, not exceeding five years, and the time within which the water shall be applied to a beneficial use, not exceeding four years after the date of completion. One-fifth of the work must be done within half of the time allowed, and in case of failure the engineer may issue other permits for the same supply.

On or before the date set for completion the engineer is to inspect the works to determine their capacity, safety, and efficiency. He may require necessary changes and shall not issue his certificate of completion until such changes are made. When the works are in satisfactory condition, the State engineer shall issue a certificate of construction, setting forth the capacity of the works and such limitations upon the right as are warranted by the condition of the works, but in no manner exceeding the rights described in the permit.

On or before the date set for the application of water to a beneficial use the engineer shall again inspect the works, and after the inspection issue a license to appropriate water to the extent of the actual application thereof to a beneficial use. The inspection for the completion of the works and that for the application of water to a beneficial use may be made at the same time if the owner of the permit wishes this to be done. Any permit or license to appropriate water may be assigned, but no assignment is binding except upon the parties thereto unless it is filed in the office of the State engineer.

DISTRIBUTION OF WATER.

For the distribution of water the State is divided into three divisions, for each of which there is to be a water commissioner. These commissioners and the State engineer form the State board of water commissioners, which is to have general supervision of the distribution of water. The engineer may make rules governing distribution, but these may be revised by the board of water commissioners. The divisions may be divided into districts as it becomes necessary to the economical and satisfactory division of the water. Anyone may appeal from any act or decision of a water commissioner to the State engineer, from whom appeal may be had to the courts. Water commissioners are to be appointed by the governor to serve six years, subject to removal by the governor, and receive $5 per day for the time actually engaged in official duties, but not exceeding 100 days in any one year. This is to be paid by the State.

Ditch owners are required to put in head gates and measuring devices of designs approved by the State engineer at places determined by them, and in case these structures are not put in within twenty days after notice from the engineer the water commissioner is to refuse to deliver water to the ditch. Taking water under these circumstances is made a misdemeanor. Interfering with any dam, head gate, weir, or other structure or with any person lawfully distributing water is also a misdemeanor. These acts are punishable by fine of not more than $100 nor less than $20, or imprisonment for not more than thirty days, or both fine and imprisonment.

MISCELLANEOUS.

Water rights are made appurtenant to land, except that when it becomes impracticable or uneconomical to use the water upon the land in connection with which the right was acquired it may be transferred to other land, provided this can be done without injury to other rights, but this can be done only upon application to the engineer and publication of a notice of the intended transfer for four weeks in a newspaper of general circulation in the stream system in which the land is located. Upon receipt of proof of publication the State engineer shall render his decision regarding the transfer, and his decision is final unless appealed from to the court.

The State engineer may inspect any irrigation works which he deems unsafe and order such changes as may be necessary to render them safe, and must make such inspection on the application of any party who puts up the estimated cost of the inspection. He may also inspect works under construction and order any changes necessary to secure safety. The fees for such inspection are a lien upon the property of the owner, and the use of any works declared unsafe is a misdemeanor.

The engineer is to fix rates for carrying and delivering water where canals supply water to the lands of others than the owners of the canals.

Where natural channels are used for conveying water the engineer is to determine what deductions shall be made for losses by seepage and evaporation.

FEES

The engineer is to collect in advance and pay into the State treasury the following fees:

For filing and examining an application for permit to appropriate water, and map of the same, $5. For recording any permit, certificate of construction, or license issued or any other water-right instrument, $1 for the first hundred words and 15 cents for each additional hundred words or fraction thereof. For filing any other paper, $1. For issuing certificates of construction or license to appropriate water, $1 each. For making copy of any document recorded or filed in his office, 15 cents for each hundred words or fraction thereof. For blueprint copy of any map or drawing, 10 cents per square foot or fraction thereof. For other copies of drawings, actual cost of the work. For certifying to such copies, $1 for each certificate. For examining and approving plans and specification for any dam not exceeding 10 feet in extreme height from the foundation, $10. For a dam higher than 10 feet and not exceeding 30 feet, $20. For a dam higher than 30 feet and not exceeding 50 feet, $30. For a dam higher than 50 feet, $50. For inspecting dam sites and construction work when required by law, or when necessary in the judgment of the State engineer, $10 per day and actual and necessary traveling expenses. The fees for any inspection deemed necessary by the State engineer, and not paid on demand, shall be a lien on any land or other property of the owner of the works, and may be recovered by the State engineer in any court of competent jurisdiction. For such other work as may be required of his office, the fees provided by law.

OKLAHOMA.

Oklahoma in 1905 adopted a code of water laws similar to those of North and South Dakota. This provides for the bringing of suits for the determination of water rights by the attorney-general of the Territory after hydrographic surveys have been made by the Territorial engineer, for the intervention of the Territory in suits brought by private parties to determine water rights, and for the making of hydrographic surveys by the Territorial engineer upon the order of any court which is adjudicating water rights.

Rights are to be acquired by application to the Territorial engineer, who has authority to refuse them upon the ground of hostility to the public interests or an insufficient supply.

The water is to be distributed under the supervision of the Territorial engineer by commissioners appointed by the governor. The law makes no provision for the appointment of a Territorial engineer at the present time, but provides that until such appointment is made the secretary of the board of agriculture shall do the work of the engineer.

NEW MEXICO.

The office of Territorial engineer was created in New Mexico in 1905, but, as in South Dakota, no appropriations were made for salary and expenses, and the law has not been put into effect. It provides merely for the adjudication of existing rights, and follows the Wyoming system exactly (see p. 20). The board of control is composed of the Territorial engineer and six water commissioners. The Territory is divided into six divisions, for each of which there is one commissioner. When a stream is to be adjudicated the commissioner for the district in which it is located collects the testimony as to dates of appropriation, etc. The Territorial engineer makes surveys; the testimony is open to inspection; protests are allowed and heard, and all the evidence collected, and the maps made are submitted to the board at the next meeting, when the rights are defined by the board and certificates issued. This law provides that all the natural waters within the limits of New Mexico belong to the public and no person shall be be denied the right to appropriate said waters for beneficial use. This is similar to the provision of the Colorado constitution, which has been held by many to prohibit the State from prescribing the manner of making such appropriations and from giving the engineer or any other official authority to reject any application for permission to appropriate water on the ground of there being no unappropriated water in the source of supply or for any other reason. This point has never been squarely decided by the Colorado supreme court, but the opinion above cited is very generally accepted in Colorado. If this view is correct, rights must be acquired without public supervision until this provision of the law is repealed.

Parties wishing to construct dams must submit plans to the Territorial engineer. For large works he may require excavations to determine the character of the foundations and may visit the location of such works before giving his approval, and no rights may be acquired if such works are built without the approval of the engineer. He has authority to inspect any dam within the Territory of New Mexico, and if he finds it in an unsafe condition he may order such repairs as he deems necessary. If the owner refuses to make the repairs ordered, the engineer reports the case to the judge of the district court, who may order the sheriff to draw off the water from the dam and keep it drawn off until the repairs are made.

GENERAL DISCUSSION.

As was stated in the introduction to this report, the primary purpose of the creation of the office of State engineer in irrigated States is the distribution of the water to those entitled to its use. The engineers in the various States have other duties, but these are incidental. A first requisite for this distribution is well-defined rights. Without this the engineer has no basis on which to distribute water. Notwithstanding this, the great body of rights in the United States were acquired without such supervision as would definitely limit and define them. Because of this fact the first step in providing for the distribution of water has been the provision of a method for defining existing rights. The second step is a provision for the acquirement of rights under such public supervision as will insure a complete list of those rights. The essential things are that the list must be complete and that the rights must be accurately defined. In so far as they fall short of this the basis for distribution is faulty. The laws of the various States providing for the defining and acquiring of rights must be judged by this standard—do they provide for a complete and accurate list of all rights to water?

The first laws looking to the provision of a list of rights were those regarding the filing of copies of notices of claims with the county officials. Such laws have been in existence in practically all of the States. These have notoriously failed of their purpose, for the reason that there was no limitation on what could be claimed and no record of what was done by the claimant after the claim was filed. It has always been a fundamental principle of irrigation law that a right to water could be acquired only by diverting and using the water. A record of claims, therefore, has no value as a record of rights. Up to the present time no other provision for securing a record of rights as they are acquired has been made in California, Montana, and Washington, except that in Montana a person having completed irrigation works may file with the county a map and statement showing what has been done.

A second step was a provision for the filing of claims with the State engineer, as well as with the county officials, the purpose being to have in one place a complete record of all claims within the State. This provision has also failed. This is the present system in Colorado and Oregon. Under these laws there was no provision for determining what rights had been acquired, the rights remaining undefined until they were brought before the courts in suits between rival claimants to the same source. In such suits only the rights of the parties to the suits would be defined, the complete defining of the rights of all parties on a single stream under this system requiring an infinite number of suits. To prevent this most of the States have since adopted a provision that in any suit regarding water rights all persons claiming rights to water from the same source may be made parties to the action. Colorado has gone further and provided a special procedure to be followed by the courts for defining rights. This system avoids the multiplicity of suits, but it makes no provision for a complete list of rights, as no adjudication will take place until conflict has arisen. While this is a serious defect this system has been criticised more severely on the ground of inaccuracy in defining rights. This has been especially true of the operation of the law in Colorado. In that State there is no provision for expert advice as to capacity of ditches, which is usually determined from the testimony of the interested parties. This has resulted in decrees confirming to claimants rights to many times as much water as they had ever used or their ditches would carry, and these decrees have been the source of some of the most serious difficulties which have arisen in irrigated districts in Colorado.

As a direct result of the inaccuracy of this Colorado system of defining rights, Wyoming adopted its system under which rights are determined very largely by administrative officers on data secured by surveys and measurements made by experts, and rights are limited not by the capacities of the works, but by the needs of the lands watered. In this way greater accuracy has been secured, but from the standpoint of the officer charged with the distribution of water the greater advantage of the Wyoming system is that under it it is possible to secure a complete list of all existing rights. The board of control which defines rights is not compelled to wait until conflicts have arisen, but as soon as its means will permit may make the measurements and collect the data for determining the rights on any stream and make its order defining them. If funds had been provided it would have been possible within a very few years, under the Wyoming law, to define all the rights within the State, but funds have been limited, and after sixteen years there are still many undefined rights in Wyoming. This system has been copied with slight modifications in Nebraska, Nevada, and New Mexico. In Nebraska and Nevada the process was simplified by leaving to the board of irrigation the procedure under which rights are defined. In both these States it has been left to one man, the State engineer, to make the surveys, collect the testimony, and define the rights, reserving, in Nebraska, the right of appeal to the State board and later to the courts, and in Nevada to the courts. In Nebraska this resulted in the complete defining of existing rights within a very few years. The Nevada law has been in effect but three years, but the determination of rights there is much more rapid than in Wyoming.

In the other States it is very generally held that the determination of rights is a judicial matter, and can not therefore be delegated to an administrative officer. In those States there has been an attempt to secure the advantages of the Wyoming system and still leave the matter in the courts, provision being made for surveys by the State engineer whenever suits regarding water rights are begun. This provision has been adopted in Idaho, where, however, it is discretionary with the court whether the engineer will be called in, and in Utah, Oregon, North and South Dakota, and Oklahoma. But these laws are of so recent date that their efficiency has not been tested. For the sake of providing a complete list of rights where their defining is left in the courts, the State engineer or some subordinate has been authorized to begin actions after making such surveys and measurements as are necessary. This provision has been adopted in Idaho, Utah, North and South Dakota, and Oklahoma. The only State where this system has been tested is Idaho, where it was declared void, because the official authorized to bring action was held not a party in interest and therefore not competent to bring an action for the defining of rights. In Utah the engineer has begun surveys and the collection of data preparatory to beginning an action in the court, but has not proceeded far enough for the law to be ruled upon by the court. In the other States the laws have not yet become effective. There is a difference in detail in these States, which, however, does not seem to affect the main question on which the Idaho law was declared void. In Utah the engineer is to submit the data collected to the clerk of the court in some one of the counties in which the stream lies, while in the other States the data is to be turned over to the attorney-general, who is then to begin an action in the name of the State.

It appears, then, from a study of the operation of the laws for defining water rights in the various States that so far the only effective means of securing a complete list is to have the work done by an administrative board or official, subject to review by the courts. The provision contained in the newer laws for the bringing of actions by the attorney-general in the name of the State may prove effective, but it seems doubtful in view of the decision against the Idaho law.

In the States which have provided a system for supervising the acquirement of rights the necessity for adjudicating existing rights will in a few years pass away, since all new rights will be defined as they are acquired, and, naturally, the time will soon come when all rights acquired before the passage of the laws providing for supervision of the acquirement of rights will have been defined. In the States where rights are still acquired by appropriation the necessity for a system of defining rights will continue to exist.

The essentials of a system of controlling the acquirement of rights are the same as those for defining rights—accuracy and completeness. The system adopted for securing a complete record are in general similar in the States which have adopted any system. There must be an application to the State engineer, stating the intentions of the applicant and describing the works to be built, approval of this application by the State engineer, and submission of proof of having complied with the conditions of the approved application. For completeness this is all that is essential, and some States stop with this. Colorado, for instance, requires the engineer to approve any filing which contains a clear statement of what is claimed, while Idaho requires the engineer to approve any application which is made in proper form. Colorado, however, has no provision for inspection or proof of completion, and its requirement of filings by those wishing to appropriate water is of no value from the standpoint of furnishing a list of rights.

For accuracy most of the States require an examination of the plans submitted with the application and surveys or examinations of the completed works, and, in some States, of the land irrigated, in order that rights may be limited to the quantities of water which have been put to a beneficial use. Utah allows, instead of this examination, sworn statements by the applicant and two disinterested parties, although the engineer may make examinations if he deems it necessary. A compulsory examination by the engineer has its drawbacks. When the works are small or situated in remote districts the expense for examination is greater than is justified by the value of the rights. It has, therefore, been recommended in some States where examination is required that the engineer be allowed to accept sworn statements for remote and unimportant works, as is done in Utah. North and South Dakota and Oklahoma accept certificates of competent engineers for small works.

The engineers in several of the States have been given authority to reject applications for various causes. It should be noted that such authority is not necessary for the accomplishment of the main purposes of public supervision of the acquirement of rights. Both accuracy and completeness can be secured without this authority for rejection. It must be based, therefore, on reasons of policy outside of the main purpose of the law. The most common cause for rejection is the fact that there is no unappropriated water in the source of supply. It is an apparent absurdity to require the engineer to approve an application for the diversion of water from a stream which contains no water to which a right can be acquired. But there is something to be said in favor of approving application on streams which are already fully appropriated. The flow of a stream is not fixed, but increases and decreases from year to year, the flow in the latter part of the season almost universally increasing as the lands along its banks are irrigated, while the water requirements of land under irrigation have a tendency to decrease. The engineer is not, therefore, in a position to state that there is at any time no unappropriated water in a stream to which rights can be acquired. Decrease in use under existing rights, increase in flow due to seepage, and occasional supplies from unusually high floods may at any time furnish some supply for a new ditch. The Wyoming practice in regard to the rejection of applications upon this ground seems to be better than the Idaho practice. In Idaho the engineer approves all applications which are in proper form, making no reference to the supply which may be secured, while in Wyoming the engineer approves such an application, but stamps across the face of it a statement warning the applicant that the stream is very largely appropriated; that there is doubt as to his being able to secure any water, and that he must not interfere with existing rights. This system gives warning to the applicant, but at the same time allows him to proceed with construction if he thinks the chance of securing water is great enough to justify him in building works. If the works are built he will be in a position to take advantage of any supply which may become available on account of more economical use, return seepage, or wet seasons.

Most of the States give the engineer authority to inquire into the feasibility of the project and the conformity of the plans to correct engineering principles. This is justified as a protection to property, and is a desirable exercise of public supervision.

The engineers are also given authority to inquire into the financial ability and good faith of applicants. With the exception of Idaho none of the States goes into any detail on this matter. Idaho requires the filing of a bond as a guaranty of good faith. Without such inquiry by the engineer or the filing of a bond as required in Idaho, it is possible for the parties having no means for carrying out works or those wishing merely to delay or hold up some legitimate project to file applications which are purely speculative, without any intention or ability to build works. The protection of the State's resources makes it essential that there should be some such check upon speculative filings. The Idaho requirements for the filing of a bond and payment of a filing fee of 10 cents for each cubic foot per second after the first seem to be preferable to general authority for the State engineer to inquire into the financial ability and good faith of the applicant, since the exercise of this authority by the engineer subjects him to charges of favoritism, and leads to ill feeling on the part of those whose applications are rejected.

Wyoming, the pioneer State in providing for the public supervision of the acquirement of rights, gives the engineer authority to reject applications which are contrary to public policy. This has been followed by most of the States which have adopted codes in recent years. This provision is so general in its terms that it may be interpreted to mean much or little. In Wyoming charges of favoritism were made against the engineer, and the exercise of this authority has given him a great deal of trouble. The engineer of Nevada holds that this provision gives him no authority to reject applications which conform to the general rules of the office. The Utah engineer held that this provision gave him authority to choose between possible uses and refused an application for a use which in his opinion was not the best possible use of the water. Appeal was taken to the courts, the engineer was overruled in this matter, and at the next session of the legislature the law was repealed. In the other States which have adopted this provision the law is not yet effective. It appears, therefore, that this law is either ineffective or unpopular with both the engineers and the public. It seems very doubtful whether such discretion or such a burden should be put upon an officer, as it leaves room for charges of discrimination and appeals to the courts. It seems to be better to leave to the legislature the determination of what is good public policy, making the engineer a strictly administrative officer, who is to see that these principles are enforced.

Rights may be transferred in all of the States with the possible exception of Nebraska. In order that the list of rights may at all times be correct, it is necessary that these transfers be recorded with the State engineer. Correctness and accuracy require nothing more than this. It is, however, a fundamental part of the law of transfers that they can be made only when the rights of others are not injured. Originally there was no provision for determining in advance of the transfer whether the rights of others would be injured thereby. The usual procedure was to make the transfer, after which those claiming to be injured were compelled to bring action to prevent it. This placed the burden of determining whether a transfer might be made upon those who might be injured rather than upon those who are to receive the benefit. Recognizing this, Colorado requires that the party wishing to make a transfer apply to the court having jurisdiction of the stream, and the transfer is allowed only after a hearing similar to that held in connection with defining rights. Idaho, Nevada, North and South Dakota, and Oklahoma require that application must be made to the State engineer, who is to hold hearings, after a proper advertisement, and determine in advance whether a proposed transfer can be made without injury to other rights. Wyoming gives the engineer authority to recognize a transfer or refuse to do so, after which either party may appeal to the court. Since the question whether the transfer of a right will injure others is entirely one of physical facts and does not involve any legal questions, it seems that this matter is more properly left with the State engineer, who is a hydraulic engineer, than with the courts. The essential requirements regarding transfers are that there shall be a record and that it shall be determined in advance whether the rights of others will be injured.

Having a complete list of all rights to water, the officer charged with its distribution needs also a knowledge of the supply with which to satisfy these rights, and all the States having engineers provide for the making of stream gaugings. It is also essential that he have means of measuring accurately the quantity of water delivered, and means of controlling this. Most of the States have provided for this by requiring ditch owners to put in head gates and measuring devices on the request of the water officials. Various means of enforcing this provision, in case the owners refuse to put in the structures, have been tried, such as having the official put them in and collect the cost through the county commissioners or by suit in the court, or having the county commissioners put in the structures and tax the cost against the property of the ditch owner. All such systems have proved ineffective, partly because county commissioners are apt to be in sympathy with the ditch owners and refuse to act, and partly because of the delay which is unavoidable where so many different agencies are required to act. The only provision which has been uniformly effective is giving the water officials power to refuse to deliver water to parties who do not comply with their orders within a reasonable time.

While the systems of distribution in the various States having public officials for this purpose differ in detail, they are in general the same. The essential thing is that the districts be as nearly independent as possible, and that all rights which are in any way interdependent come within the jurisdiction of a single official. Colorado was the first State to provide for this, and its system is still the model. The State is divided into divisions formed on drainage lines, each of which is entirely independent, putting each stream system under the control of a single division engineer. These are subdivided into districts which are also formed on drainage lines, but are not entirely independent. Each of these districts is served by a commissioner, who is under the general direction of the division engineer. The methods of meeting the cost of distribution differ widely. In some States it is paid by the counties and in others assessed against those using the water. This does not seem to be a matter of great importance. It may very properly be assessed against the users of the water, since they are the principal beneficiaries of the work, or it may be paid by the county as a sort of bonus to the industry, justified on the ground of the great public benefit derived.

TABULAR SUMMARY.

Public control of water, 1905.

State or Territory.	Defining of rights.	Acquirement of rights.		Distribution.
		Initiation.	Proof of completion.	
Arizona	No provision	Post and file notice.	No provision	No provision.
California	do	do	do	Do.
Colorado	Courts, on application of interested party.	do	do	Public officials.
Idaho	Courts—surveys by State engineer when ordered by court.	Application for permit.	Inspection by State engineer.	Do.
Kansas	Courts	Post and file notice.	No provision	Court officers.
Montana	Courts—all claimants parties; no surveys.	do	File maps	Do.
Nebraska	Administrative — secretary, board of irrigation.	Application for permit.	Sworn statement and inspection.	Public officials.
Nevada	Administrative—State engineer.	do	Rules not made	Do.
New Mexico	Administrative—board of control.	File notice	No provision	No provision.
North Dakota	Courts—surveys by State engineer.	Application for permit.	Inspection by State engineer.	Public officials.
Oklahoma	Courts—surveys by Territorial engineer.	do	Inspection by Territorial engineer.	Do.
Oregon	Courts—surveys by State engineer when ordered by court.	Post and file claim.	No provision	No provision.
South Dakota	Courts—surveys by State engineer.	Application for permit.	Inspection by State engineer.	Public officials.
Utah	do	do	Sworn statements	Do.
Texas	No provision	File notice	No provision	No provision.
Washington	Courts—on application of any interested party.	Post and file notice.	do	Public officials.
Wyoming	Administrative—board of control.	Application for permit.	Inspection by superintendent.	Do.

Irrigation officials in the arid States, 1905.

Officials.	Appointed by	Term.	Salary.	Paid by
Colorado:				
State engineer	Governor	2 years	$3,000 per year	State.
Division engineers	do	do	$125 per month	Do.
Water commissioners	do	Not fixed	$5 per day	Counties.
Idaho:				
State engineer	do	4 years	$2,000 per year	State.
Water commissioners	do	6 years	$10 per day	State and counties.
Water masters	Water commissioners.	1 year	$4 per day	Users.
Kansas: Water bailiffs	Courts	Not fixed	$2 per day	Counties.
Montana:				
State engineer	Governor	4 years	$2,500 per year	State.
Water commissioners	Courts	Indeterminate	Not fixed	Users.
Nebraska:				
Secretary State board	State board	2 years	$2,000 per year	State.
Under secretaries	do	do	$5 per day	Do.
Under assistants	do	do	do	Counties.
Nevada:				
State engineer	Governor	Not fixed	$2,400 per year	State.
Water commissioners	State board	do	Not fixed	Counties.
North Dakota:				
State engineer	Governor	4 years	$2,500 per year	State.
Water commissioners	do	6 years	$10 per day	Do.
Water masters	Water commissioners.	Indeterminate	$4 per day	Users.
Oklahoma:				
Territorial engineer[a]				
Water masters	Territorial engineer		$3 per day	Users.
Oregon: State engineer	Governor	4 years	$2,400 per year	State.
South Dakota:				
State engineer	do	6 years	$2,000 per year	Do.
Water commissioners	do	do	$5 per day	Do.
Utah:				
State engineer	do	4 years	$3,000 per year	Do.
Superintendents	State engineer	Indeterminate	Fixed by engineer.	Do.
Supervisors	County commissioners	do	$3 per day	Counties.
Washington: Water commissioners.	do	1 year	Not fixed	Do.
Wyoming:				
State engineer	Governor	6 years	$2,500 per year	State.
Superintendents	do	4 years	$1,200 per year	Do.
Water commissioners	do	2 years	$5 per day	Counties.
Secretary board of control.	Board of control	Indeterminate	$1,200 per year	State.

[a] Duties prescribed but no provision for appointment.

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 169.

A. C. TRUE, Director.

REPORT

ON

AGRICULTURAL INVESTIGATIONS IN ALASKA,

1905.

BY

C. C. GEORGESON, M. S.,
Special Agent in Charge of Alaska Experiment Stations.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., April 30, 1906.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 169 of this Office a Report on Agricultural Investigations in Alaska for 1905, by C. C. Georgeson, M. S., special agent in charge of the Alaska agricultural experiment stations.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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REPORT ON AGRICULTURAL INVESTIGATIONS IN ALASKA, 1905.

WEATHER CONDITIONS.

In Alaska the weather is the controlling factor which determines the degree of success attainable in agriculture. During the season of 1905 the weather was favorable to agricultural operations in the coast region. The months of July and August were bright and warm, and the gardens throughout that region were quite successful. In the interior, on the other hand, conditions were somewhat less favorable. The spring was late, raw, and overcast. Seeding was therefore late and early growth was slow. In July and early August the weather was favorable, but during the middle and latter part of August the weather was rainy and overcast, which retarded the ripening of the crops. Conditions were not uniform throughout the interior. In the Yukon and Tanana valleys the settlers complained of too much rain and not enough sunshine. In the Copper River Valley there was not enough rain, and killing frosts began in the latter region as early as August 14. Light frosts occurred in the Yukon Valley on several days the latter part of August, but no killing frosts destructive to hardy plants occurred until September. Hence the grain crops matured at the Rampart Station, although they were late, while only a small percentage matured in the Copper River Valley because of an early killing frost.

SUMMARY OF THE SEASON'S WORK.

SITKA STATION.

It was explained in last year's report that the work of the Sitka Station would in the future be devoted chiefly to horticulture. In conformity to this plan two lines of work were undertaken which it seemed most important to prosecute: (1) The introduction, propagation, and testing of fruit trees and fruit bushes, with a view to ascertaining what sorts, if any, can be successfully cultivated in Alaska; and (2) the testing of varieties of vegetables best suited to the climate and the soil in various parts of the Territory.

As to the introduction and propagation of nursery stock work begun last year was continued. Among fruit trees attention has been chiefly directed to the apple as the one most likely to succeed in far northern latitudes. Only summer varieties have been selected, and these again of only the hardiest sorts. It is almost certain that the season in any part of Alaska is too short to mature fall and winter varieties, but summer apples which, in more southern latitudes, mature in July or early in August may possibly have time to develop before the cold weather sets in. As stocks, seedling apples of hardy varieties have been chosen. Several thousand of these seedlings have been grafted at the station, and some have been purchased already grafted. A few trees of each of the promising varieties have been planted at the station with a view to noting their behavior, but the majority have been or will be sent out to all parts of the Territory to be tested. It will take some years before results can be secured from which it is safe to draw conclusions. Success in fruit growing is problematic at best. At Wrangel are two trees known to the writer which have matured apples. There is a native crab apple in southeastern Alaska (*Pyrus rivularis*), but it is little more than a bush, though specimens have been found with trunks 5 or 6 inches in diameter. It is of slow growth, and on that account it is doubtful if it would have any value as a stock on which to graft. The apples are about the size of sour cherries, but they are much valued for jelly. When the weather is cold and rainy during the flowering period, the last of May, these native crab apples fail to set fruit. This would point to failure also of better varieties under similar conditions. Among the varieties considered for introduction, we have selected several of the crab apples and their hybrids as being on the whole the most promising sorts.

The nursery stock at the station has not grown as vigorously as it would in a better soil and warmer climate. This is in part due to the soil, which has not as yet been brought into satisfactory condition. Our efforts to improve it will be briefly mentioned later. A year ago there were slight signs of fungus diseases appearing on the nursery stock. The past season this evil increased so that we found it necessary to spray with Bordeaux mixture several times. These sprayings kept the attacks in check, but they nevertheless had a retarding effect on the growth. This nursery work will be continued and extended.

While there may be some doubt of the success of fruit trees, there is no doubt whatever concerning the success of fruit bushes in almost all parts of Alaska south of the Arctic Circle. Raspberries and currants grow wild, and cultivated varieties of these bush fruits are grown with marked success everywhere they have so far been tried. In the coast region raspberries, currants, and gooseberries grow better and yield more fruit than they do in regions east of the Rocky Mountains. It is planned to test as many varieties of these as can be obtained at slight cost, in order to determine what sorts do best.

Strawberries have been only a partial success at the Sitka Station. The cultivated varieties so far introduced have been winterkilled, not, indeed, as the result of cold weather, but by repeated freezings and thawings, which caused the plants to be heaved out of the soil, even when protected by a covering of spruce boughs. In some places strawberry culture is quite successful, as, for instance, at points on Prince of Wales Island, at Killisnoo, and in some gardens at Skagway. The native Alaskan strawberry has been brought under cultivation, and though it grows well it is found to produce very little fruit. Efforts will be made to produce hybrids between this native berry and some of the cultivated varieties. In this connection I will mention that we succeeded last year in cross-fertilizing the cultivated raspberry with the salmon berry (*Rubus spectabilis*), which grows wild throughout the coast region. The two plants do not bloom at the same time, the salmon berry being out of bloom before the raspberry begins. To overcome this we planted raspberry bushes in boxes and kept them in the greenhouse, and the periods of blooming of the two were thus adjusted to correspond to each other.

In the line of vegetable growing efforts were directed chiefly to potatoes, cabbage, and cauliflower, though small beds of all the hardy vegetables were grown. The work will be continued. The soil on which these tests were made is new and raw, the best soil having been given over to the nursery work. A piece of new ground in front of the cottage has been grubbed and drained. This has, however, only proceeded when time could be spared from the cultivated ground. It is not completed and will be continued as time and means may permit.

BURNING LIME.

For the purpose of procuring lime to apply to the land at less cost than it can be purchased in the local markets, we have tried the experiment of quarrying limestone from a ledge of that material located some 14 miles from Sitka. The launch and scow belonging to the station were used for hauling the rock home, where it was burned. It was impracticable to burn it at the quarry because the frequent rains would slack the burned lime, and it was out of the question to build a rain-proof shelter. The experiment was a success so far as it went. Good, active quicklime was made, and the fuel used consisted mostly of roots and stumps from the clearings. The labor involved is considerable, however, and in the absence of a limekiln, which it would not pay to build, only a little over half of the rock was burned sufficiently each time. Two methods of piling the fuel and rock were tried. In one case a foundation of logs 12 feet long was laid on the ground; on this another layer of logs was laid crosswise, and on top of this 2 or 3 feet of roots and stumps. A layer of lime rock, broken in sizes of 6 or 7 inches in diameter, was piled on top 1 foot thick. Then the pile was built up with alternate layers of fuel and lime rock until it was 12 feet high. Slabs (the outer cuts from logs), obtained from a local sawmill, were nailed outside the whole pile and the chinks between these closed with sod to exclude the inrush of cold air so far as possible. The top of the pile was also covered with sod, and to secure a good draft a flue was built in the center by placing old barrels, with the bottoms knocked out, on top of each other as the pile was built up. When all was ready a can of lowest grade kerosene obtainable was poured over the whole and the fire started. The result was a success, as stated, to the extent of burning rather more than 50 per cent of the limestone.

In the other case a pit 12 feet in diameter was dug 6 feet deep, and the fuel and rock were piled in alternate layers as before. Here the slabs were not needed. The earth excluded the air more effectively than the slabs did. The results were practically the same. Settlers who have convenient access to a ledge of limestone can burn lime in this way. More would be burned at the station but for two circumstances. One is that the launch is disabled, so that the limestone can not be hauled, and the other is a fall in the price of lime on Puget Sound, by which it can be laid down at the station at $1.67 per barrel of 200 pounds, all charges paid. At this rate there will be little if anything saved by burning the lime, when all the items of quarrying, hauling, and cutting and transporting the fuel, etc., are counted.

COOPERATION WITH SETTLERS.

As in former years, the station has enlisted the cooperation of the settlers throughout the Territory in the testing of varieties of vegetables, by the distribution of seeds for their use. Seeds are sent to those who desire them with the understanding that at the end of the season they are to write a detailed report of the results obtained. Very many of them neglect this duty; others, however, do write interesting and valuable reports, some of which are published under the head of "Reports from the seed distribution." The object is twofold—first, to ascertain as far as possible what varieties of vegetables are best suited to certain regions, and, second, to ameliorate the conditions of life among the settlers and prospectors by helping them to raise gardens.

In this connection we desire to give grateful acknowledgment to the chief of the Bureau of Plant Industry, Dr. B. T. Galloway, and to Mr. A. J. Pieters, in charge of seed and plant introduction and distribution, who have furnished the seed for this purpose.

As noted, we have extended this cooperation by the distribution of selected fruit trees and fruit bushes. Only a limited number of trees were available last year, so only a few were sent to each person, and we were unable to fill all the applications received; but it is planned to continue and extend this work. It is of vital importance to ascertain which varieties, if any, of the tree fruits can be successfully grown in Alaska, and it is likewise important to stock the Territory with fruit trees, if any are found which will mature fruit. The apple is at once the most important and the most likely fruit to mature. This is therefore given chief attention. The varieties under experiment are enumerated in the notes (page 27).

METEOROLOGICAL WORK.

The cooperation with the United States Weather Bureau in collecting meteorological data has been continued during the past year. The Weather Bureau supplies the instruments required for voluntary observer's stations. They consist of a maximum and a minimum thermometer and a rain gauge. The special agent establishes the stations wherever it is thought desirable one should be located, provided a reliable permanent resident can be found to undertake the work, which is wholly without compensation. Monthly reports from all these stations are sent to the special agent at Sitka, who conducts the correspondence and issues supplies as needed. It is a most important work and should be continued for a long period of years, but it involves considerable office work.

COPPER CENTER STATION.

The work of this station is devoted chiefly to grain growing. About 40 acres in all have been cleared, and the past season this area was divided into about 200 plats and cropped mainly to grain, but also to grasses and vegetables. Only a small percentage of the grain matured this year. Early frost is the bugbear of this station. This is the third year since work was begun here. In 1903 the first frost occurred August 27. At that date nearly all the grain had matured, so the outlook was quite encouraging. In 1904 the first killing frost occurred August 17. At that time only the earliest varieties had matured. But this year a severe killing frost occurred August 14, before any but the very earliest sowings of the earliest varieties had matured. Owing to the fact that we have but one team and only one man employed the period of seeding necessarily extends over some three weeks, the past year from May 9 until the close of the month. Now, it is found that the varieties sown before May 15 have matured, at least in part, whereas those sown later than that date were totally killed by frost and had to be cut for hay. In no case did a variety mature as completely as could be desired. The following varieties matured in part: Kharkov winter wheat and Ladoga spring wheat; Excelsior winter rye; Champion, Lapland, and Manshury barleys, and, to a less extent, Chevalier, Odessa, Black Hulless, Hanna, and Primus barleys. The following varieties of oats matured in part: Finnish Black, Banner, Russian No. 2800, Tartar King, Sixty-Day, the Improved Ligowo, and Burt Extra Early.

Attempts are being made to develop varieties which will mature by the middle of August, and there is scarcely any doubt but that we shall succeed in this. The earliest maturing heads will be selected and saved for seed, and this selection will be continued year by year until the result sought is obtained.

It is a rather remarkable fact that killing frost did not occur at the Rampart Station in the Yukon Valley, 3½ degrees farther north than the Copper Center Station, until September. While there were six light frosts at Rampart in the latter part of August none of these injured the grain seriously, and the crops therefore matured. For some reason, as yet unexplained, the Copper River Valley appears to have killing frosts earlier than the Yukon Valley.

Rapid-growing vegetables did fairly well. Peas were especially successful, and the varieties known as "Alaska" and "Prolific Early Market" matured seed before the killing frost of August 14. Turnips and ruta-bagas succeeded nearly everywhere. The Broad Windsor bean, it is worthy of notice, produced edible pods, but it failed to mature seed before the frost. All the clovers were winter-killed. There is therefore but little hope that the perennial clovers can be grown as ingredients of the pastures.

In the interior grain hay will always be an important crop. In this connection attention is called to the fact that rye gave a better yield than oats or other grain.

IRRIGATION MAY BE NECESSARY.

One point which has developed since work began in the Copper River Valley is that the rainfall there is very light, and it is feared it will be insufficient for the normal development of grain crops, at least in some seasons. The rainfall from October 1, 1904, to September 13, 1905, at the Copper Center Experiment Station, was but 9.8 inches. Of this only 3.05 inches fell during the months of May, June, July, and August. The remainder represents mostly snow, which fell during the winter. This looks as though irrigation would be necessary to insure normal development of crops. Owing to the drought in the early part of the summer, much of the grain was too short to cut.

FERTILIZERS IMPROVE THE YIELD.

It is further to be noted that the soil is not naturally rich. Where fertilizers were applied there was an increase in the yield of straw, which, in some cases, amounted to double the weight obtained on unfertilized plats. Alaska soils are, as a rule, not fertile, except on alluvial deposits near the mouths of the rivers or elsewhere where silt has accumulated. There is but a small amount of vegetable mold in the soil. In the coast region, where the rainfall is abundant, vegetation is luxuriant nearly everywhere, but in the interior, where the rainfall is scant, the native vegetation is not abundant. Consequently, but little humus is accumulated. Owing in part, also, to the same cause, disintegration of the rocky material is not so complete as it is in more southern latitudes; that is, the soil, as a rule, contains a large percentage of gravel. These conditions combine to make the addition of fertilizers very desirable. The fertilizer used the past season was fish guano, an Alaskan product manufactured at Killisnoo.

FALL PLOWING ESSENTIAL.

An important point to note in regard to grain growing in the interior is that the land should be fall plowed. This will save labor in the spring, when it will be only necessary to go over the field with a disc harrow in order to put it in condition for seeding. All who attempt to farm in the interior should, therefore, make an effort to plow the land thoroughly immediately after the crops are gathered in the latter part of August or the beginning of September.

EARLY SEEDING NECESSARY.

Another important point is to get the seed in the ground as early as possible. Begin seeding in early May whenever it is possible to work the ground, and let nothing interfere with the work until all the seed is planted. Early seedings may be caught by frost, but late seedings are sure to be.

RAMPART STATION.

While the Rampart Station was reserved in 1900 and a small clearing of about half an acre made, no one was regularly employed at this station until July, 1904, when Mr. Fred. E. Rader, formerly assistant at Sitka, was made superintendent of the station. He went to work at once and cleared about 2½ acres of land in that year, 2 acres of which were seeded for the first time in the present season. During the summer of 1905 the clearing was continued, and he has now about 5½ acres ready for the plow. The cleared portion was seeded to grain and planted to vegetables. It has already been noted that most of the grain matured, although the seeding was late, the first grain being sown May 18. The summer was not altogether favorable. It was colder than usual, with more cloudy and rainy weather than is normal in that region, and the early growth was slow. Mr. Rader's report (see p. 55) shows that nearly everything matured. Winter rye ripened satisfactorily, but winter wheat, on the other hand, did not fully ripen. These fall-sown grains were partly winter-killed from the fact that the snowfall was very light, and as the snow was the only protection the grain was killed where the snow was thinnest. The writer visited this station in the middle of July and again on August 10. On these dates the prospects were not favorable for the harvest; but seasonable weather continued throughout the month of August, and as the frosts which occurred in the latter part of that month were not severe enough to injure the grain the crops ripened.

Ten thousand feet of lumber were purchased to be used in the building of a house at this station, which is planned to be put up during the summer of 1906. The logs for this lumber were purchased from the contractor who had supplied Fort Gibbon with logs for buildings, and they were sawed and transported through the courtesy of officers of the War Department.

Rabbits are so numerous about Rampart as to be a veritable pest. Both grain and garden crops have to be fenced rabbit proof. In the absence of such protection, everything is eaten to the ground. Part of the cleared ground has been fenced by driving barrel staves in the ground and part will be fenced with wire netting.

KENAI STATION.

The writer visited Kenai Station in early September. There are 25 acres under cultivation at this place, all of which was seeded to grain. Only once since the first crop was harvested, in 1899, has grain matured at this station. The summers are too cool and cloudy and, though the rainfall is not excessive, there is a lack of the sunshine which is so necessary for the grain. Last season's crop was intended only for feed and consisted chiefly of oats, though some barley was also grown. These grains made a good growth, and by the beginning of September the grain was in the milk, and thus afforded most excellent feed. The fall was so dry that all the grain was cured for hay.

Pursuant to the plan announced in last year's report, this station will in the future be devoted chiefly to dairying. A small herd of native cattle has been reared at the station, the cows being purchased in the village three and four years ago. There were four cows in milk last summer, which, with the heifers, calves, and yoke of oxen, made a total of thirteen head. From this number the superintendent sold a cow and a calf, leaving eleven to be wintered. Part of the milk has been sold and part made into butter, which found a ready sale at from 35 to 40 cents a pound. A dairy equipment suited for about twelve cows has been purchased and sent to this station, and the manufacture of butter and cheese will hereafter be the main feature of the work there, aside from the growing of feed and experiments with forage plants.

RESERVATION AT FAIRBANKS.

The people of Fairbanks petitioned the Secretary of Agriculture last winter for the establishment of an agricultural experiment station at some suitable point in the Tanana River Valley. As a result, the special agent in charge was instructed to examine the Tanana Valley and, if a suitable location was found, to make a reservation for possible future use as an experiment station. Pursuant to these instructions the writer left Sitka on July 9 and went down the Yukon by way of Skagway and Whitehorse, arriving at the Rampart Experiment Station on the evening of July 17. Two days were spent at this station. Superintendent Rader, with one hired man, was hard at work clearing land. The crops on the cultivated ground looked well, but they appeared to be rather late. This was due to cold, wet weather in the spring and early summer. Plans were perfected for the building of a small house for the use of the station, and Mr. Rader and the writer left Rampart July 19 and arrived at Baker, 80 miles from Tanana, July 23. After examining the region about the Baker Creek Hot Springs (concerning which a statement will be made elsewhere in this report), they returned to the river and arrived at Fairbanks July 28. Three days were spent in exploring the country in various directions from Fairbanks, with a view to finding a suitable location for the purpose of an experiment station. The best situation was found to be a tract of land which lies nearly midway between Fairbanks and Chena, and which adjoins the Tanana Mines Railway, now completed between these two towns, with a main line running to the mines. Accordingly, a survey was made of this tract, field notes and map of which are submitted herewith. On the return trip the station at Rampart was again visited while the boat remained in port, and it was noted that the crops had made good progress during the preceding three weeks.

Referring to the map submitted herewith (fig. 1) it will be seen the tract selected lies in the angle formed by the Fairbanks branch of the Tanana Mines Railway and the main line of this road, which forms a junction with the line from Chena to Fairbanks, nearly midway between the two towns, and runs out to the gold diggings some 20 miles distant. The tract comprises 1,393.97 acres. It is in many respects ideal. A low ridge of hills runs almost parallel to the railway, beginning near the southeast corner of the reservation and extending in a westerly direction three-fourths of the distance across the tract. This ridge is covered with fine timber, consisting of almost equal proportions of spruce and birch. When cleared it will afford a fine southern slope for culture. The northward slope of this ridge is more gradual than that on the south side. It is timbered in the same way, though the timber is smaller. In the northwest corner of the tract is another elevation, which affords slopes

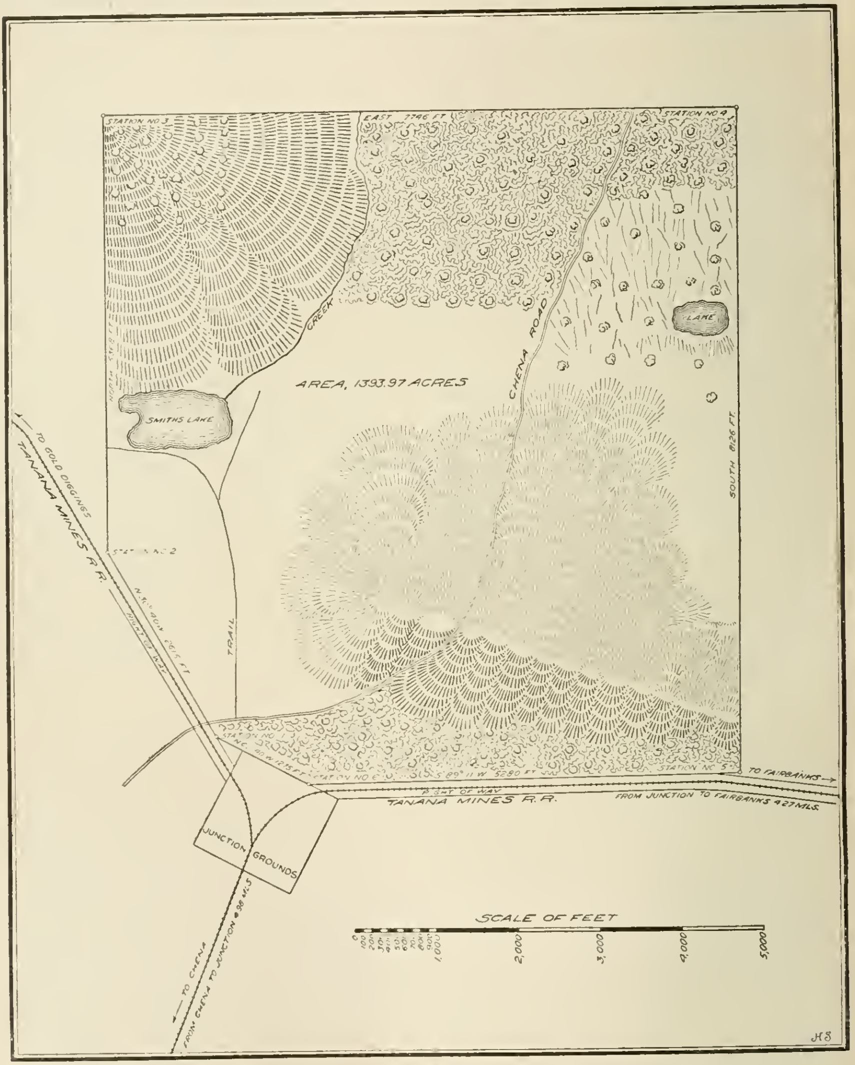

STATION NO 3
EAST 7746 FT
STATION NO 4
CREEK
CHENA ROAD
LAKE
AREA, 1393.97 ACRES
SMITHS LAKE
NORTH
SOUTH 8126 FT.
TO GOLD DIGGINGS
TANANA MINES R.R.
STATION NO 2
N. 40 W 2615 FT
RIGHT OF WAY
TRAIL
STATION NO 1
N. 40 W 1275 FT
STATION NO 6
S 89° 11 W 5280 FT
STATION NO 5
TO FAIRBANKS
RIGHT OF WAY
TANANA MINES R.R.
FROM JUNCTION TO FAIRBANKS 4.27 MLS.
JUNCTION GROUNDS
TO CHENA
FROM CHENA TO JUNCTION .98 MLS
SCALE OF FEET
0
100
200
300
400
500
600
700
800
900
1,000
2,000
3,000
4,000
5,000
HS

Fig. 1.—Map of proposed United States reservation for experiment station purposes between Fairbanks and Chena, Alaska.

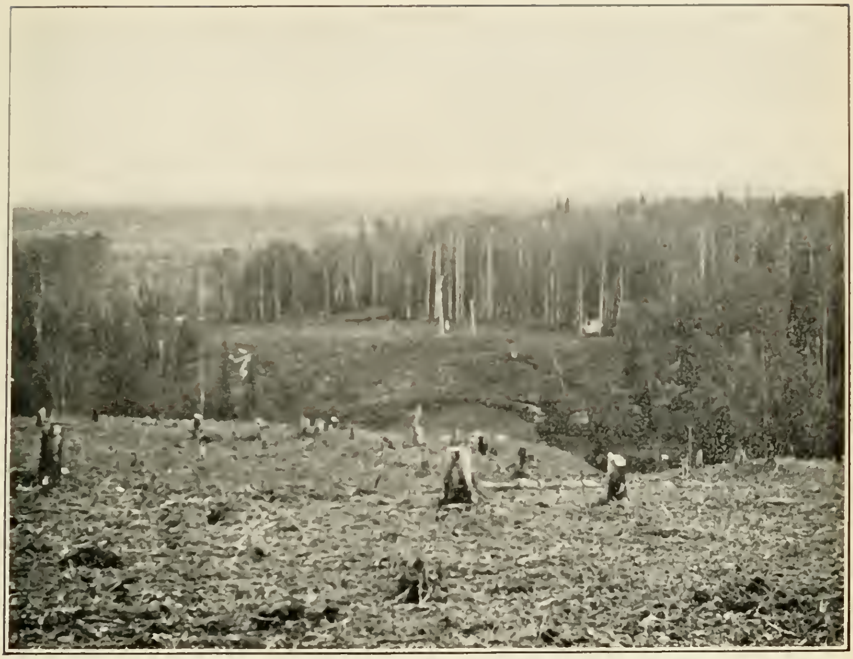


FIG. 1.—VIEW OF TANANA VALLEY FROM HOT SPRINGS FARM.

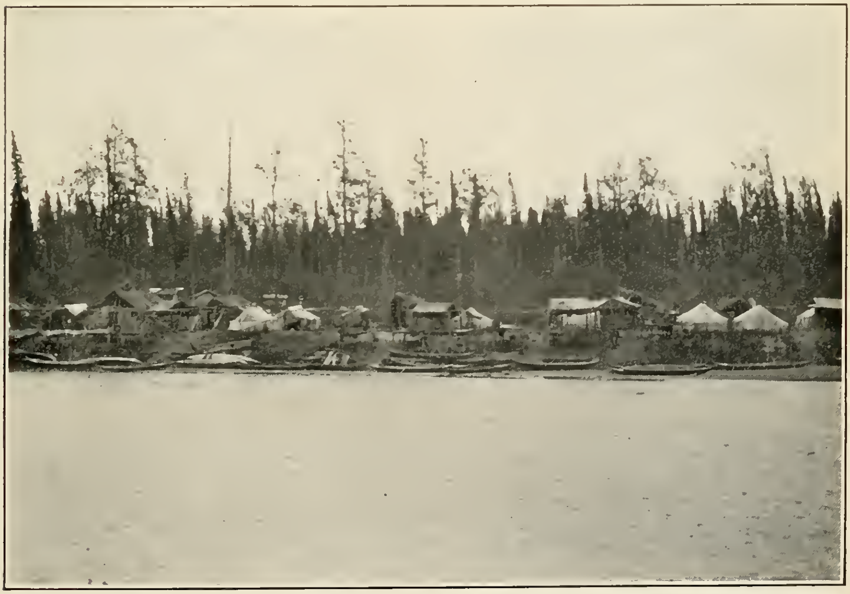


FIG. 2.—NENANA, INDIAN VILLAGE ON THE TANANA.

to the south, southeast, and east, of excellent soil, timbered chiefly with spruce and birch. Through the center of the tract from east to west the ground is somewhat low, and there are two lakes, one named Smiths Lake, about 25 acres in extent, and the other, which is unnamed, about 5 acres in extent. Immediately surrounding these lakes is some low, swampy ground, but the waste ground of this nature, and including the lakes, will not exceed 100 acres, all told. The rest of the tract is comparatively level. It has been covered with small timber, but this timber has been destroyed by a fire, which apparently occurred some years ago, and only the dead, charred trunks now remain to tell of the former forest. More than half of these dead trunks have been overturned by the wind and lie scattered in all directions. This timber is small, from 5 to 8 inches in diameter in most cases, though there are some larger trunks. The ground is covered with a scattered growth of low bushes, very prominent among which is the black huckleberry. There are also scattered patches of grass, but there is no general or dense luxuriant growth of grass, unless the sedges on the swampy land and around the lakes be so considered. The writer saw moose tracks in several places, but squirrels were the only wild animals encountered in the woods. A road, which leads from Chena to the mines, runs through the tract, as indicated on the map, and there is also another trail running from near station No. 1, on the southwestern corner, to Smiths Lake and beyond. The shaded hillsides are covered with green timber, the rest of the tract with dead timber and bushes, as stated. The writer considers it an admirable tract of land for an experiment station, and being located on the railway, there will not be the trouble in the transportation of supplies and equipment that was experienced at the Copper Center Station. The top soil everywhere consists of a thin layer of muck, which grows thicker, reaching a foot or more in depth on the lower ground. Below this is a yellow, rather sandy loam. Portions of the tract can be cleared and broken at slight expense.

The Tanana Valley is undoubtedly well adapted to agriculture as we now understand the term in connection with Alaska (Pl. I, fig. 1). The valley is wholly distinct from that of the Yukon, being separated from it by high mountains. According to the reports of settlers and prospectors who have lived in this valley for longer or shorter periods, the climate is milder here than in the Yukon or in the Copper River valleys, and all agree that the spring is at least three weeks earlier in the Tanana Valley than it is in the Yukon Valley. Eighty-two homesteads have been taken up and recorded in the Fairbanks recording district. The proximity of the mines and the wide extent and apparently rich gold deposits make it certain that there will be a large population in this valley for many years to come, and as this population will need grain, forage, and vegetables for its support and for work animals, it appears to be highly desirable that an experiment station should be started at this point. I recommend that this reservation be set aside as an agricultural experiment station, and that work be begun, even though it be on a small scale, during the year 1906, if possible.

THE TANANA VALLEY.

The Tanana River is a stream of majestic proportions. It takes its rise in the high mountains in about latitude 62° N., near the Canadian boundary, and runs in a northwesterly direction until it joins the Yukon in latitude 65°. Including the bends and turns in the river, it is about 600 miles in length, though that portion of the valley adapted to agriculture is but about 400 miles long. The river carries a large volume of water, and in places it spreads over a large area. It is navigable to river boats of good size from its mouth to Fairbanks, a distance of 267 miles. For a distance of some 60 miles upstream from Fairbanks the river is divided into a number of shallow channels through which the water flows with great rapidity. In this portion it is navigable only by small and very powerful boats, strong enough to stem a 12-mile current; but beyond this area it is navigable again for more than 200 miles.

The valley inclosing this river has an average width of about 25 miles and consists in the main of a rolling country, densely wooded with spruce, cottonwood, and birch. At a rough estimate the valley contains 15,000 square miles, most of which can be utilized for agricultural or grazing purposes.

The principal settlement is at Fairbanks, 267 miles from the Yukon. The town itself has a population of perhaps 3,000 people, but it is estimated that there are some 10,000 or 12,000 people in that region scattered among the creeks and in the mining camps which have sprung up on the various creeks. Chena, some 12 miles farther down the stream, is a prosperous little town with a fine townsite. There are a few white settlers at Nenana (Pl. I, fig. 2), Kantishna, Tolovana, Baker Creek, and at the famous Hot Springs. At the mouth of the Tanana is Fort Gibbon, where some 200 soldiers are stationed, and a town is springing up in the neighborhood. Above Fairbanks are a few small mining camps, the principal one being at Delta.

HOT SPRINGS, TANANA VALLEY.

Some 80 miles from the mouth of the Tanana, a so-called slough, i. e., the stagnant water in an old closed channel, joins the Tanana. Following this slough for a distance of 6 miles one reaches the famous hot springs of the Tanana. The agricultural conditions here are so unique that, although they were mentioned in last year's report, the writer ventures to return to the subject more particularly, because an opportunity was offered to study the characteristics of the location during the summer of 1905. There are several small hot springs bubbling out of the ground near the head of the slough. The country is strongly rolling, forming a series of knolls and hills, and between and at the bases of these are a number of seepages of hot water. A prospector named J. F. Karshner, who was formerly a farmer in Kansas, happened on these springs, and, correctly estimating their importance, located a homestead, including the springs. He began clearing land, and the following year, that of 1903, he planted his first garden. He met with such remarkable success that he has extended the clearing and continued his gardening operations.

The unique feature of the situation is that the ground over an area of some 25 or 30 acres appears to be warmed, either by the presence of the springs, or, perhaps, from the underlying hot rocks which heat the water. This ground thus forms a natural hotbed. Ordinary garden crops develop with great rapidity. When visited July 24 he had already marketed his early cabbage, cauliflower, carrots, and peas, to say nothing of radishes, lettuce, turnips, and other crops of rapid growth. His new potatoes were fully grown and of excellent quality, and the ground from which the early cabbage and cauliflower had been removed was already planted to the second crop of cabbage. For a hotbed a tent was stretched over a suitable patch of soil and seed sown under it. The natural warmth in the ground, which is not, however, so great as to be readily perceptible to the hand, was sufficient to grow the plants in the month of April to such size that they could be planted in May. The possibilities of the place are very great. Mr. Karshner grows beans, cucumbers, squash, Lima beans, and last year there were likely looking plants of both muskmelons and watermelons growing on the hillside. It is a patch of the Temperate Zone put down near the center of Alaska.

The illustrations submitted herewith show the nature of the vegetables (Pl. II). The timber on this land is mostly poplar. Men were at work clearing when the writer was there. The accompanying statement from Mr. Karshner gives further details of his operations. He finds a market for all he can produce at Fairbanks.

Farming in Alaska will prove all right in the future when once it is understood what kinds of grains, grasses, and vegetables will do well, and we learn how to grow them. Agricultural products grown here must be managed differently from what they are in the States to make it profitable. It is especially necessary to learn what kinds are adapted to this country.

As to potatoes, seed brought from the States does not yield as good a crop as the seed raised here. I have taken note of that for the last two years, and I suppose it will hold good with all kinds of vegetables and grains. Only time and experiments can determine this with certainty. I shall try to raise more seed of my own. I must cite you another case in point, and that is peas. I sowed peas of the earliest I had last year and planted them side by side with the same kind I had sent me by a seedsman in Wisconsin with the result that my home-grown seed produced peas fit for use at least five days earlier than the other. So also with potatoes: I got larger and earlier ones from my own seed.

Now, as to the financial side: I suppose you wish to know the prices my crops brought, and I quote as follows: Cauliflower, 40 cents per pound; cabbage, 25 cents per pound; celery, 50 cents per bunch. These held good for the season's crop, but the others fluctuated. Potatoes, 22 cents per pound, and at the end of the season 9 cents per pound; beets, 30 to 10 cents per pound; parsnips, 20 to 18 cents per pound; peas, 25 to 20 cents per pound; turnips, 20 to 8 cents per pound; ruta-bagas, 15 to 10 cents per pound. As to squash, tomatoes, and cucumbers, the cucumbers did fairly well, but I can improve the crop by a different method of planting and caring for them. The squash did not do as well as the first year's crop because the season was unfavorable, the latter part especially being too wet and cold. I had a few squashes. Corn commenced to fill out, but did not mature for the same cause. The tomatoes grew too strong in branches. I had quite a number of small green tomatoes. They did nothing but blossom until I trimmed the tops, then fruit commenced to form. People took them for potato tops. I will prune severely in future. I am satisfied I can raise them here.

WORK WITH LIVE STOCK.

It is recommended that the small appropriation which Congress has allowed for experiments with live stock be used to purchase cattle and sheep adapted to the climate of Alaska. The Galloway and the West Highland cattle are the hardiest breeds in this country. As many head of one of these, or of both of them, as can be purchased and transported to Alaska with the available funds should be procured. What is needed is a general-purpose animal—one which makes good beef and which can at the same time be used for the dairy. The Galloways are the most numerously represented, and can be purchased for less than the West Highlanders. It is therefore proposed to select Galloway cows with good milking qualities—for, although they are essentially beef cattle, there are some good milking families among them—and, with these cows as a foundation, develop a hardy, all-purpose strain, suited to Alaska conditions.

If the appropriation will permit, it will also be highly desirable to purchase a few head of West Highland cattle. This is a purely beef breed, suited to the rigorous climate and noted for their rustling qualities. Cattle of that class will be of the highest value to Alaska in time to come.

The introduction of hardy sheep is almost equally important, and a portion of the appropriation should be used for this purpose. The Blackfaced Scotch breed, and the Danish breed, which has for long periods of years been bred in Iceland, should be purchased if they can be procured in this country. These are among the hardiest sheep, and it is safe to say that they will do better in Alaska than any so far tried here.

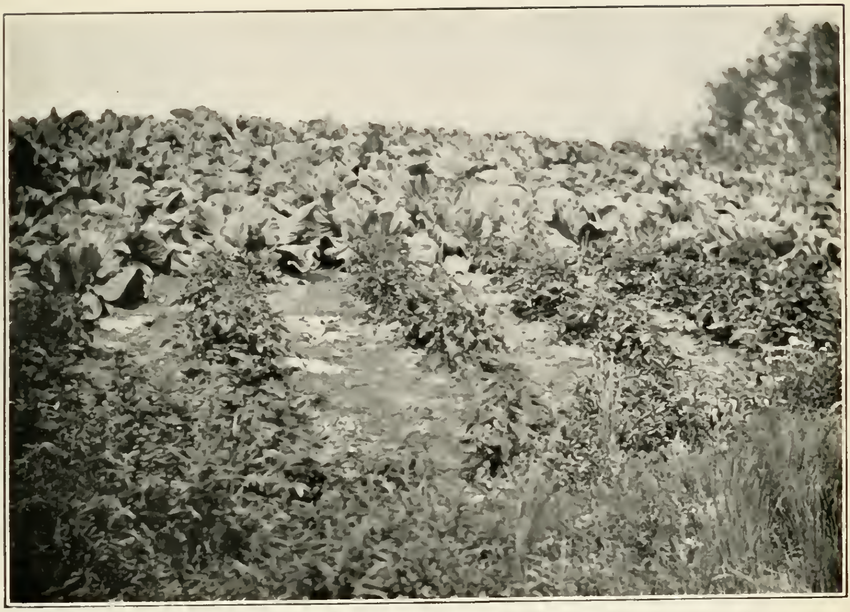


FIG. 1.—VEGETABLES, HOT SPRINGS FARM ON THE TANANA.

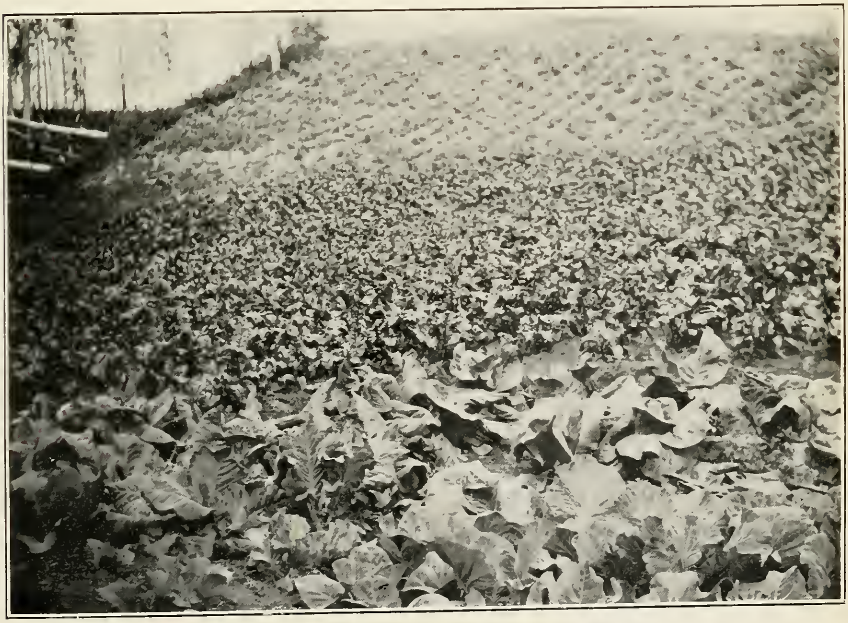


FIG. 2.—VEGETABLES, HOT SPRINGS FARM ON THE TANANA.

It is proposed, if the necessary money is appropriated for this purpose, to select from twenty-five to fifty head of sheep, either of the Blackfaced Scotch breed or Iceland sheep, or both. When animals of this character are introduced they should be bred primarily with a view to develop those qualities which are of first importance to meet Alaska conditions, namely, hardiness and usefulness for general domestic purposes. In the view of the writer the offspring in excess of that required for the experiment stations should be sold to settlers in Alaska for breeding purposes. They would thus aid in stocking the Territory with cattle which the ordinary pioneer could not afford to introduce. Congress has appropriated something over $200,000 for the introduction of reindeer in Alaska, a measure which in itself is very commendable and highly beneficial to the Territory, but may it not be assumed that cattle and sheep would be of equal value?

It would be greatly to the advantage of the Territory if an appropriation of $10,000 were made for the establishment of a live-stock station on Kodiak Island, such station to be stocked with cattle and sheep of the above-named breeds. Kodiak is mentioned as the most desirable place for such a station because it affords abundant pasturage, and a breeding station could be maintained there at less cost than elsewhere in the Territory. Some buildings would be needed, but this item would not be costly. Hardy stock could run out nearly the year round, and one competent man would be all the labor needed. Kodiak is, moreover, accessible at all times. Boats touch here regularly, and stock could be shipped to all ports on the coast and from there to interior points with equal ease. If there were sufficient natural pasturage at Sitka, this point would be chosen in preference, because the headquarters for the station work are located there; but the natural pasturage is lacking. Neither can the Kenai Station be chosen, for the reasons set forth below.

SITUATION AT KENAI.

The economic conditions on the Kenai Peninsula, particularly as regards transportation, are undergoing an important change. The Alaska Central Railway is building from the new town of Seward, at the head of Resurrection Bay, and will run across the neck of the peninsula to the towns of Hope and Sunrise, and on northward around the head of Knik Arm and through the valley of the Sushitna to the gold fields on the Tanana (Pl. III). This railroad will doubtless carry the traffic destined for the interior and for the northern part of the peninsula, and when completed as far as Sunrise, which will be during the next few months, the traffic on Cook Inlet, which has been chiefly maintained on account of the settlers at Turn-Again Arm, will undoubtedly cease, either in part or altogether. This will leave the Kenai Station inaccessible except by hiring special conveyance. It is therefore recommended that steps be taken to remove this station to a suitable location somewhere on the railway, the place to be selected after the road is built and in operation.

This change in transportation could not possibly have been foreseen at the time the station was located at Kenai, in 1898. It was then expected that the peninsula would be settled by people who would work in the newly discovered placer mines and in the coal fields, which were then being opened up in the peninsula; but neither the coal fields nor the placer mines have made any progress.

HOMESTEADS.

The writer has taken pains to ascertain how many homesteads have been recorded to date in Alaska. Reports have not been obtained from all recording offices, but those heard from are as follows:

Circle	5
Fairbanks	82
Copper Center	11
Skagway	33
Juneau	36
Sitka	6
Yakutat	6
Catalla	3
Valdez	39
Seward	59
Total	280

It is probable, however, that many of these homesteads have been taken up for the value of their timber rather than for the purpose of utilizing the land for agriculture.

GRASS INVESTIGATIONS.

It is hoped that the very valuable work which was begun by Professor Piper in the summer of 1904, by his investigations of the grass lands along the coast region of Alaska, can be continued. The native grasses and forage plants of the interior have never been investigated by a specialist. The force employed by the Alaska stations can not be spared from their regular duties for this work. It is therefore respectfully recommended that steps be taken to continue cooperation with the Bureau of Plant Industry in this work. If that Bureau could send a man to do the work, Alaska stations might possibly undertake to defray half of his expenses while so engaged in Alaska, the resulting information to be at the disposal of the Bureau of Plant Industry and the Alaska stations.

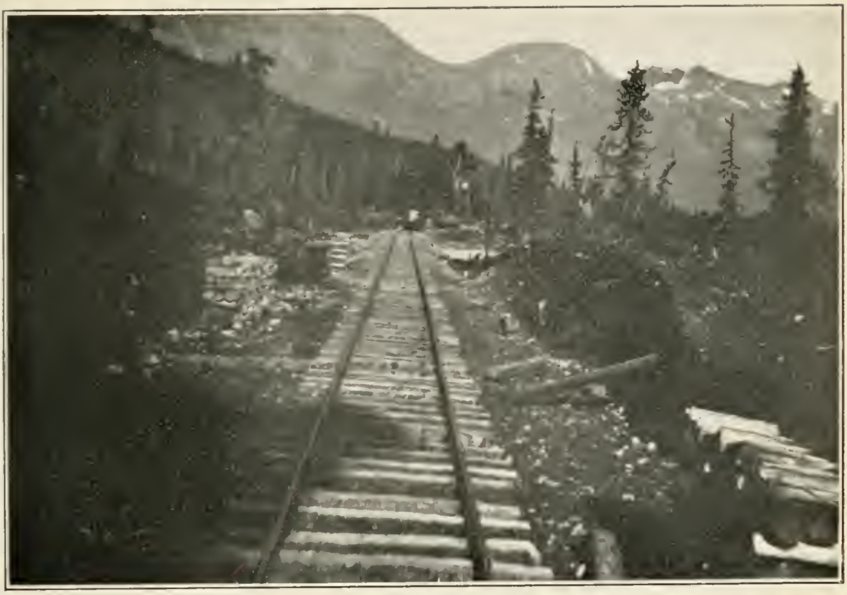


FIG. 1.—VIEW ON ALASKA CENTRAL RAILWAY.

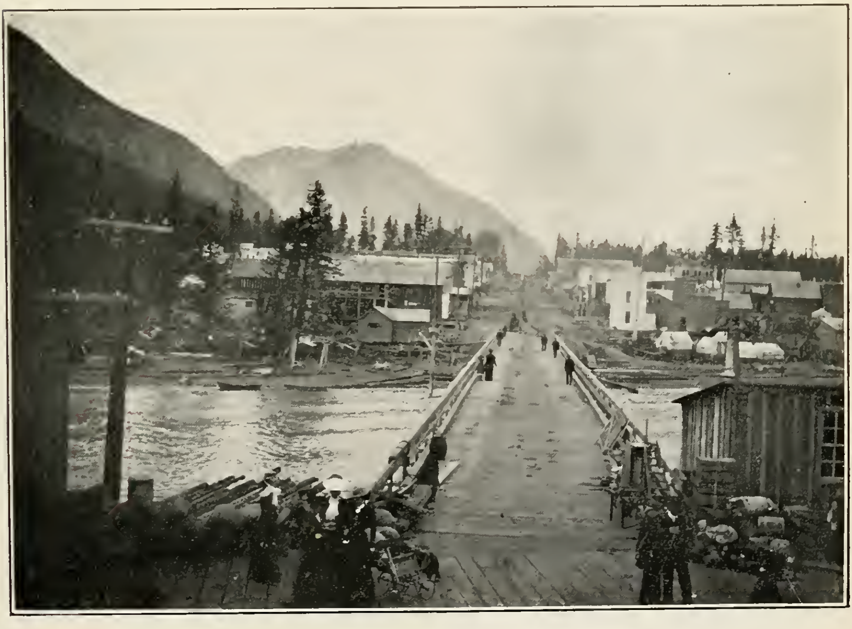


FIG. 2.—TOWN OF SEWARD, RESURRECTION BAY, TERMINUS OF ALASKA CENTRAL RAILWAY.

IMPORTS OF FARM PRODUCTS.

During the fiscal year ending June 30, 1904, farm products were imported into Alaska to the value of $3,340,899. This total includes many things grown in tropical regions, as coffee, rice, sugar, tobacco, nuts, etc., and it also includes whiskey, wines, beer, etc., which are manufactured from farm products, but deducting all of these, the following interesting figures show the imports into Alaska for the year named:

Imports into Alaska during the year ended June 30, 1904.

Animal products:		
Live animals	$190,900	
Dairy products	454,736	
Eggs	164,471	
Beef, fresh, cured, and canned	272,536	
Pork	241,111	
Other meat products	84,962	
Miscellaneous animal products	118,806	
Total animal products		$1,527,522
Vegetable products:		
Vegetables, fresh, dried, and canned	333,550	
Grain and grain products	392,922	
Fruits	231,062	
Hay	120,084	
Total vegetable products		1,077,628
Total animal and vegetable products		2,605,150

This will give an idea of the market that Alaska affords for these products, a very large percentage of which could be produced in the Territory.

FORESTS IN THE INTERIOR.

The writer desires to call special attention to the forests in the interior. They are of such importance that they should, in his opinion, be accorded Government protection for the benefit of coming generations. The chief forest belt of the Territory lies in southeastern Alaska, and the most valuable portion of this belt has already been set aside as a forest reserve. This is highly commendable; but it is even more necessary to preserve the smaller timber of the interior. The forests make life possible there. Without them the white race would have to live as do the Esquimo. To import the timber needed for fuel, for mining, for buildings, and for structural purposes of all kinds would be well-nigh impossible, and the prices would be prohibitive. At interior settlements, right in the midst of the forests, lumber is worth $100 per thousand board feet, and at the mines, as, for instance, on Cleary Creek, less than 20 miles from the sawmills at Fairbanks, the writer was informed that it was regularly sold at $225 per thousand feet. What it would be worth if it had to be imported can scarcely be imagined. While the forests appear to the pioneer of the present to be an impediment to progress, their value will be increasingly appreciated as the country settles and years pass. It is the forests of the interior that have the greater value and should receive the most fostering care. Enormous areas of timber in that region are annually destroyed by forest fires, to say nothing of that consumed for steamer fuel and other legitimate purposes. Coming generations will sorely miss this timber. It can not be replaced. Growth is slow in those latitudes. If the indiscriminate destruction is not stopped, or at least regulated, and existing forests jealously guarded, development must suffer and be retarded, if not made impossible. In the timber belt of the coast region there is but little danger from forest fires. The rains are an efficient preventive. And the forest-clad gorges and mountain sides in that region are, as a rule, so inaccessible that the timber does not readily fall a prey to the woodman's ax. Nature herself protects the forests there. In the interior they are open to every sort of destruction and their loss will be grievously felt.

The spruce (*Picea alba*) is the dominating tree. It covers practically all the best land; only the swamps and steeper hillsides and the tops of the hills are void of it. Intermixed with the spruce is a liberal sprinkling of birch and cottonwood, especially on the higher ground. The timber is not large. In the Tanana Valley spruce ranges in size all the way from mere saplings to trees which measure 18 to 20 inches in diameter. Logs from 12 to 15 inches in diameter are abundant. On the basis of $100 per thousand feet, the stumpage in the Tanana Valley is worth all the Government paid for the whole Territory. It is an invaluable asset. The building of towns and the operations of placer mining would be well-nigh impossible in the absence of timber. It is being utilized. At Fairbanks the writer found three sawmills in constant operation, sawing an average of 30,000 feet of lumber a day. The question arises if it would not be wise for the Government to make forest reservations in the interior also, with a view to preserving a portion, at least, of this timber for the use of future generations. After a somewhat careful study of the situation, the writer ventures the opinion that what is needed is supervision to avoid waste, rather than withdrawal from use. The waste is not so much from destructive lumbering as it is from ravages by fire. Fires are of frequent occurrence, and with the influx of prospectors and settlers their frequency will increase unless the Government takes active measures to prevent them. Lumber is indispensable to the development of the country, and, if reservations were made, free use of the timber by miners and settlers should not be prohibited. Rather the whole forest area should be treated as a trust fund, administered for the benefit of the people who live in the country. Regulations could be formulated for the use of timber and for the prevention of fires, and supervisors should be on the ground to enforce them; but care should be taken that they in no wise work a hardship on the people or deter the development of mining and agriculture. Fines for violations should go toward the cost of administration, and, if necessary, a very small stumpage fee might be charged for the same purpose. The use of the timber should be limited strictly to the needs of the people who live there and develop the country. No pulp mills or other manufacturing plants, which would consume timber for purposes alien to the needs of the dwellers on the soil, should be permitted.

The writer believes that a policy applicable only to the interior, along the lines here roughly indicated, would be of great benefit to Alaska.

ANALYSES OF SOIL FROM SITKA STATION.

The following report by Dr. Milton Whitney, Chief of the Bureau of Soils, on analyses of samples of soils sent him from the Sitka Station, are submitted because they throw light on the quality of much of the soil in the coast region:

No. 1. Sample of subsoil which is frequently thrown to the surface, and, in places where knolls have been leveled, now constitutes the surface soil.

	Per cent.
Nitrogen	0. 05
Acid digestion:	
C_aO	Trace.
P_2O_5	Trace.
K_2O	. 07

No. 2. Sample of subsoil found somewhat deeper than No. 1.

	Per cent.
Nitrogen	0. 08
Acid digestion:	
C_aO	. 47
P_2O_5	. 12
K_2O	. 67

No. 3. Peaty subsoil found in hollows and spots. Sterile to agricultural plants.

	Per cent.
Organic and volatile matter	93. 8
Nitrogen	. 46
Acid digestion:	
C_aO	. 46
P_2O_5	Trace.
K_2O	. 17

No. 4. Surface sample on peaty land which had been cleared and put in cultivation. The sample sent has been on the surface of the ground for one year. It is sterile until lime is added.

	Per cent.
Organic and volatile matter	96.42
Nitrogen	.50
Acid digestion:	
CaO	.47
P_2O_5	.07
K_2O	.13

ANGORA GOATS AT COPPER CENTER.

The following letter from Judge Andrew Holman shows some possibilities regarding Angora goat production in Alaska:

Dear Sir: Early in August this year we received from Monmouth, Oreg., 26 Angora goats—25 grade ewes and 1 registered buck; for the latter we paid $25, and for the ewes we paid $4 apiece. It took nearly a month to get them here, but they stood the trip better than I had expected; not one showed any signs of exhaustion. But of course they ran down in flesh and were pretty thin when they came here.

They commenced to pick up at once, however, and now they weigh easily 20 per cent more than they did when they came; and the beauty of it is that they are not at all inclined to be roving and give us absolutely no trouble. They have been left entirely to their own free will, but they keep close to their camp. Only once have they gone over 500 yards from camp, and then they were driven by dogs.

It was my fear at first that we should have everlasting trouble with dogs, but we found it took only a few days to train the dogs living around us to let them alone, and the Indians have instructions to keep their dogs away, with which they comply very well. But if they do get after them, they only chase them and the goats run for camp, so we have had very little trouble in that way.

Now, as for the future prospects for their propagation here, I will give my opinion just as I have studied it out. I have come to the conclusion that we have here in the Copper River Valley an almost ideal place for their propagation, as it seems that the most important thing with them is to have a dry climate with plenty of young brush, which is just what they have here. In the first place, most of the land in the valley runs in benches from the Copper River and its tributaries, and all this land, up to quite recently, or until the white man commenced to come in, has been covered with more or less heavy timber. But lately a great deal of it has been burnt off, and as soon as a fire runs through the timber a second growth of cottonwood and willow grows up just as thick as it can stand; consequently there are thousands of acres of such land, seemingly just what the goats want. Of course the most important thing is what they will do in the winter, but this much I have already learned: It is now along in October, and the feed for other kinds of stock is of very little help and has been so for some time, but the goats are doing as well now as they were during the summer, and it will not be any different until the snow gets deep. It is evident, therefore, that if they are not wholly self-sustaining, they are at least much more so than any other kind of stock; and if we have to provide feed for them during midwinter, that can be done much cheaper than for other stock.

Goats are browsers and eat principally brush. I had two natives for two days to cut and put up this young second growth into bundles, and in two days they put up enough feed to last my 25 goats at least six weeks; it is therefore quite certain that goat raising will be a profitable industry here. It stands to reason that the fleece will be better here than at any other place farther east, because of the climate. As a meat industry it surely will be profitable for a long time to come. A goat will dress from 40 to 60 pounds, and 25 cents per pound here is cheap. From what I have already seen of the experiment, I have concluded to go exclusively into the Angora goat-raising business, with a little farming on the side. Next summer I shall get a couple of hundred more ewes to begin with.

Yours, respectfully,
ANDREW HOLMAN.

COPPER CENTER, *October 5, 1905.*

NOTES ON GARDEN AND NURSERY, SITKA STATION, 1905.

APPLES.

DWARF TREES, IN BREWERY LOT.

Sweet Bough: June 1, three trees in good condition. July 1, leaves somewhat affected with a fungus; sprayed with Bordeaux mixture. August 1, 5 inches new growth; leaves somewhat burned by the spray. September 15, trees vigorous, with no indication of leaves falling. October 1, leaves yet green; tips too tender to withstand hard freezing.

Tetofsky: June 1, three trees in good condition. July 1, sprayed with Bordeaux mixture for leaf fungus. August 1, 4 inches growth. September 15, made very little growth since August 1. October 1, tips too tender for hard-freezing weather.

Golden Sweet: June 1, three trees in fine condition. July 1, sprayed with Bordeaux mixture. August 1, 1 foot growth; vigorous. September 1, 18 inches growth; very vigorous. October 1, yet holding the leaves; tips tender.

Primate: June 1, two trees, both looking well. July 1, sprayed. August 1, 6 inches growth. September 15, one tree 18 inches new growth; other tree looks well, but has made little new growth. October 1, not well hardened for winter, yet holding the leaves.

Early Harvest: June 1, three trees, very good. Sprayed on July 1. August 1, 1 foot growth; thrifty. September 15, 2 feet growth. October 1, new wood not hardened sufficiently for winter.

Fanny: June 1, three thrifty trees. Sprayed on July 1. August 1, 2 inches of growth; very backward. September 15, 3 inches growth; trees look vigorous, but have made poor growth. October 1, leaves remain.

Keswicks Codling: June 1, three trees growing nicely. Sprayed on July 1. August 1, 9 inches growth; looking well. September 15, 1 foot growth. October 1, wood yet tender.

Yellow Transparent: June 1, three trees; leaves somewhat affected with fungus; sprayed with Bordeaux mixture. July 1, resprayed. August 1, growth uneven, average 6 inches. September 1, 15 inches growth on two trees; other tree looks well, but made little growth. October 1, tips of new wood very tender.

Red Astrachan: June 1, three trees; doing nicely. Sprayed on July 1. August 1, uneven growth; one tree vigorous. September 15, 1 foot new growth; looking well. October 15, new wood tender.

STANDARD TREES.

Fanny: June 1, five trees; tips of two winterkilled; otherwise all vigorous. August 1, 3 inches of new growth. September 15, 1 foot new growth. October 1, new wood very tender for cold weather.

Golden Sweet: June 1, five trees growing vigorously. August 1, 1 foot growth. September 15, 2 feet new growth. October 1, one tree nearly destroyed by ravens breaking off the branches; others vigorous, but too tender for hard-freezing weather.

Sops of Wine: June 1, five trees growing; do not look vigorous. August 1, 3 inches growth. September 15, 1 foot growth; looking much more vigorous than earlier in the season. October 1, tips very soft.

Summer Rose: June 1, five trees; looking well. August 1, very little new growth. September 15, made but little growth this season. October 1, yet holding leaves.

Sweet Bough: June 1, five trees; doing nicely. August 1, 6 inches growth. September 15, 1 foot growth. October 1, tips of new wood very tender.

Early Strawberry: June 1, five trees; very thrifty. July 15, leaves somewhat spray-burned. August 1, 1 foot growth. September 15, vigorous; 18 inches new growth. October 1, very tender.

Primate: June 1, five growing, but unthrifty looking. August 1, 4-inch growth; looking more vigorous. September 15, 6-inch growth; many leaves for so short a growth. October 1, trees yet holding their leaves.

Williams Favorite: June 1, three trees; rather unthrifty. August 1, 3-inch growth. September 15, 6 inches of growth; not looking vigorous. October 1, new wood tender.

Benoni: June 1, four doing well, one unthrifty. August 1, 1 foot of growth. September 15, 2 feet of growth; very vigorous. October 1, too tender for hard freezing weather.

NOTE.—These trees were all more or less injured by ravens. They were sprayed twice in July with Bordeaux mixture for a leaf fungus and given one washing with a stiff brush, using kerosene emulsion for cottony-cushion scale which had attacked them.

APPLES ON THE STATION GROUNDS.

Duchess (block 1): June 1, seventeen trees; growing but not thrifty. August 1, very backward. September 15, only thirteen trees alive; very poor.

Martha: June 1, eighteen trees; none doing well. August 1, making but little growth. September 15, sixteen trees alive; three have made growth.

Hibernal (block 1): June 1, seven trees very thrifty. August 1, 2 inches of growth. September 15, 6 inches of growth; looking well. October 1, new wood tender.

Whitney Crab: June 1, sixteen trees looking well. August 1, new growth very short, but trees look thrifty. September 15, 1 foot of new wood. October 1, new wood appears too soft for freezing weather.

Red Astrachan: June 1, fifteen trees give good promise. August 1, but little new growth. September 15, more thrifty than earlier in the season. October 1, new wood very short.

Lowell: June 1, twelve trees making feeble growth. August 1, very little new growth. September 15, leaves of good color but short growth.

Tetofsky: June 1, twenty trees look well. August 1, new growth very short; trees look fine. September 15, leaves of good color but growth short. October 15, trees yet holding leaves.

Yellow Transparent: June 1, eighteen trees looking well. August 1, growth short; leaves spray-burned. September 15, very little growth; leaves of good color. October 1, leaves yet on the trees.

Eureka: June 1, fourteen trees; five give good promise. August 1, all trees about equal; very short growth. September 15, 4-inch growth; good color. October 1, leaves yet hanging.

Sylvan Sweet: June 1, sixteen trees doing nicely. August 1, 3-inch growth. September 15, 4-inch growth. October 1, leaves green; tips very tender.

Byers Sweet: June 1, eleven trees very backward. August 1, all nearly dead. September 15, no growth; leaves have good color. October 1, leaves yet green.

Raspberry: June 1, eighteen trees thrifty looking. August 1, 4 inches of growth. September 15, 6 inches of new growth. October 1, leaves dropping; more promise of hardening new wood than with other varieties.

Red June: June 1, sixteen trees look well. August 1, very little growth. September 15, one tree made 1 foot of new growth; others made but little growth, some being nearly dead.

Maiden Blush: June 1, seven trees; three seem thrifty. August 1, not doing well. September 15, one tree made 12 inches of growth; four nearly dead; two look well, but have made little growth this season. October 1, leaves yet green.

Early Harvest: June 1, sixteen trees; seven thrifty. August 1, very backward; no growth. September 15, three trees made 6 inches of growth; others made no growth though the trees are of good color.

Patten: June 1, seven trees; five of them vigorous. August 1, 4 inches of growth. September 15, very little additional growth. October 1, leaves yet of good color.

Jessie: June 1, seven trees; not doing well. August 1, two trees made 6 inches of growth; others making no growth. September 15, two trees made 15 inches of growth; others look poorly. October 15, wood on vigorous trees too soft for winter.

Hibernal (block 2): June 1, seven trees give good promise. August 1, growth 2 inches. September 15, not doing well. October 1, very poor.

Peerless: June 1, six trees give good promise. August 1, 4 inches of growth; looking well. September 15, 6 inches of growth. October 1, wood very soft.

Yellow Transparent: June 1, nine trees doing nicely. August 1, one tree made 9 inches of growth; others 2 inches. September 15, one tree 18 inches, others from 4 to 6 inches. October 1, leaves yet hanging.

Duchess (block 2): June 1, eight trees; looking well. August 1, new growth very short. September 15, 3 inches of growth; color, good. October 1, leaves yet hanging.

Red June: June 1, three trees making good start. August 1, very little growth. September 15, leaves of good color; no growth. October 1, leaves hanging.

Hyslop: June 1, five trees look vigorous. August 1, have grown very little, but look well. September 15, 18 inches of growth; very strong. October 1, leaves yet retained.

Native Crab: June 1, five trees making good start. August 1, 9 inches of growth; two trees which dropped their leaves after being sprayed have again leafed out. September 15, 15 inches of growth. October 1, leaves have turned and wood promises to harden.

Transcendent: June 1, two trees doing well. August 1, 5 inches of growth. September 15, 8 inches of growth; very good.

NOTE.—All these trees were transplanted this spring (1905) to ground that had been thoroughly plowed, and limed at the rate of 2 tons per acre. They were sprayed twice in July with Bordeaux mixture for leaf fungus.

APPLE TREES GRAFTED AT THE STATION, 1904.

Lowell: June 15, whip graft on native stock growing nicely; crown graft on native stock doing nicely also. August 1, all doing well. September 15, 2 feet of growth; leaves of good color. October 1, wood too soft for hard frost.

Red June: June 1, whip graft on native stock, vigorous looking. August 1, growth very short, looking well. September 15, 6 inches of growth. October 1, tips soft.

Northwest Greening on native crab stock: June 1, growing nicely. August 1, looking well, but growth is slow. September 15, good color; no additional growth.

Okabena, one-year grafts. June 1, growing. August 1, 2 inches of growth. September 15, 1 foot of growth; very good.

Whitney Crab: June 1, giving good promise. August 1, looking well; 3 inches of growth. September 15, two trees very vigorous; others not looking so well.

Princess Louise: June 1, one-year grafts giving good promise. August 15, 4 inches of growth. September 15, 1 foot of growth; good color. October 1, wood very soft.

Duchess, one-year grafts: June 1, giving good promise. August 1, 3, inches of growth; most of them doing poorly.

Hibernal, one-year grafts: June 1, giving little promise. September 15, one tree 6 inches growth; others doing nothing.

Martha: June 1, one-year grafts giving some promise. August 1, growing nicely; 3 inches of growth. September 15, but little additional growth; not looking well.

Walbridge, one-year grafts: June 1, giving promise. August 1, new growth short, but looks well. September 15, one tree 8 inches growth; others appear thrifty, but the growth is short.

North Star, one-year grafts: June 1, giving promise. August 1, 5 inches of growth. September 15, growth 6 inches; doing well.

Patten, one-year grafts: June 1, starting well. August 15, 6 inches of growth. September 15, growth of one tree, 18 inches; others have made no additional growth.

Minnesota, one-year grafts: June 1, well started. August 1, 6 inches growth. September 15, one tree made a growth of 2 feet; others of 9 inches.

Jewett, one-year grafts: June 1, good promise. August 1, 13 inches of growth. September 15, growth 18 inches; very vigorous.

NEW GRAFTS, 1905.

Sixteen hundred trees of many varieties: June 1, very slow in starting, weather being cool and extremely dry. August 1, 70 per cent doing nicely. September 15, all have made good growth. October 1, very few hard enough to stand hard frosts.

Duchess and Tetofsky, top-worked on native stocks are doing well and have made a growth of 2 feet.

Pyrus baccata: June 1, fifteen small trees all doing well. August 1, strong 12-inch growth; very thrifty. October 1, leaves falling; wood promises to harden for winter.

Juneberry: June 1, nine plants making a vigorous start. July 1, strong 8-inch growth; bloom buds set. August 1, 14-inch growth; some fruit set. September 15, 18 inches of growth; fruit ripe. October 1, leaves turning.

CHERRIES.

English Morello, nine trees: June 1, very backward. August 1, one tree dead; others made an average growth of 10 inches. September 15, growth 15 inches; thrifty looking. October 1, leaves yet green.

Ostheim, fifteen trees: June 1, doing well; in bloom. August 1, some fruit set, but dropped when small; 6 inches of growth. September 15, growth 18 inches; trees looking well. October 1, leaves yet retained.

Early Richmond, nineteen trees: June 1, growing nicely. August 1, 5 inches of growth. September 15, three trees not doing well; others made 15 inches growth.

Dyehouse, nineteen trees: June 1, doing well. August 1, 5 inches growth. September 15, 10 inches growth.

Sand Cherry, six bushes: June 1, slow to start. August 1, very thrifty; 15 inches growth. September 15, 18 inches growth.

Compass, four trees: June 1, vigorous start. August 1, 6 inches growth. September 15, growth spindling.

PLUMS.

May Day, three trees: June 1, 4 inches of growth; strong. August 1, growth 15 inches. September 15, two trees very strong; other one not doing so well. October 1, leaves falling.

Forest garden, two trees: June 1, very weak. August 1, growth 8 inches; looking well. September 15, a growth of 1 foot. October 1, leaves falling.

Tomahawk, one tree: June 1, very backward. August 1, growth short, but tree looks well. September 15, 2-inch growth; good color; vigorous. October 1, holding its leaves.

Sayles, two trees: June 1, very weak growth. August 1, 12 inches growth. September 15, leaves yellow; growth 15 inches.

Hawkeye, three trees: June 1, very weak. August 1, 12 inches growth. September 15, 18 inches growth; thrifty. October 1, leaves coloring.

Wyant, two trees: June 1, starting nicely. August 15, 3 inches of growth. September 15, very yellow; growth, spindling, 6 inches.

Odegaard, six trees: June 1, leaves very yellow. August 1, doing well; growth 6 inches. September 15, good strong 8-inch growth. October 1, leaves coloring.

De Soto: June 1, four trees nearly dead. August 1, three trees growing some. September 15, three trees made 15 inches growth and promise well.

Rollingstone: June 1, one tree; making very poor start. August 1, a growth of 15 inches. September 15, 18 inches growth; vigorous. October 1, leaves dropping.

Aitkin, thirteen trees: June 1, doing well. August 1, 12 inches growth. September 15, 18 inches growth; vigorous. October 1, leaves coloring.

Prunus besseyi, fifty trees: June 1, looking vigorous. August 1, 50 per cent looking well. September 15, 6 inches growth. October 1, leaves dropping.

Seedling Americana, one hundred trees: June 1, thrifty. August 1, 6 inches growth. September 15, 15 inches growth; very vigorous. October 1, leaves coloring.

Seedlings of Wyant, twenty trees: June 1, doing nicely. August 1, growth rather spindling. September 15, average growth 15 inches; very vigorous. October 1, leaves coloring.

Seedlings of Cherry Plum, eighty-seven trees: June 1, doing nicely. August 1, a growth of 15 inches. September 15, average growth 18 inches; some 3-foot growths; most trees strong.

BUSH FRUITS.

High-bush Cranberry, one plant: June 1, growing very well. August 1, very short new growth. September 15, new growth very short, but plants look strong.

Buffalo Berry: June 1, few plants living; very poor. August 1, doing nicely. September 15, new growth short: plants look well.

Sand Cherry (Western): June 1, growing slowly; good promise. August 1, making very vigorous growth. September 15, 12 inches of growth; looking thrifty. October 1, leaves yet green.

CURRANTS.

Red Native from Sunrise, Alaska: June 1, some growing. July 1, very backward. August 1, very little growth. September 15, nearly all dead.

Red Cross, ten plants: June 1, growing nicely. July 1, looking well; 6 inches growth. August 1, 9 inches growth. September 15, leaves falling; 1 foot of growth.

Black Champion, ten plants: June 1, vigorous start; some bloom. July 1, 5 inches growth; no fruit. August 1, 8 inches growth. September 15, 15 inches new growth; leaves coloring.

Lee Prolific, ten plants: June 1, doing well; some bloom. July 1, 6 inches growth. August 1, 10 inches growth. September 1, 15 inches growth. October 1, leaves dying.

Wilder, eleven plants: June 1, thrifty. July 1, 4 inches growth. August 1, 6 inches growth. September 15, leaves coloring.

Russian Black, five plants: June 1, vigorous. July 1, 8 inches growth. August 1, 15 inches growth. September 15, 18 inches growth.

Common Red: June 1, growing nicely. July 1, 6 inches growth. August 1, 12 inches growth. September 15, not vigorous.

Ruby Castle, seventeen plants: June 1, doing nicely. July 1, 3 inches growth. August 1, very little additional growth. September 1, plants do not appear thrifty.

Black Currants, twenty-five plants: June 1, good growth; in bloom. July 1, 15 inches growth; leaves somewhat affected with fungus—sprayed with Bordeaux mixture. August 1, 20 inches growth. September 15, leaves coloring.

Native Currant: June 1, growing vigorously. July 1, strong growth. August 1, 5 inches growth. September 15, leaves coloring.

Amber-Colored, four plants: June 1, growing nicely; in bloom. July 1, 10 inches growth. August 1, 15 inches growth. September 15, leaves dropping.

Victoria, eighteen plants: June 1, thrifty; in bloom. July 1, 8 inches growth. August 1, fruit small, ripe; 12 inches growth. September 15, leaves falling.

Crandall, five plants: June 1, vigorous growth; in bloom. July 1, some fruit set; 6 inches growth. August 1, fruit not good; 10 inches growth. September 15, strong plants; leaves falling; 2 feet of growth.

Fay Prolific, two bushes: June 1, thrifty growth; in bloom. July 1, fruit set; 5 inches growth. August 1, 8 inches growth. September 15, leaves falling.

White Currant: June 1, growing well; in bloom. July 1, fruit set; 5 inches growth. August 1, 8 inches growth; very little fruit. September 15, plants thrifty; leaves falling; 1 foot of new growth.

Currant cuttings of various varieties, 3,500 plants: June 1, doing very well. July 1, making fair growth. August 1, not making the desired top growth. September 15, top growth rather short; excellent root system developed.

BLACKBERRIES.

Snyder, one plant: June 1, growing nicely. July 1, making slow growth. August 1, 8 inches growth. September 15, too tender for winter weather.

Taylor, seventeen plants: June 1, looking well. July 1, making good growth. August 1, new canes 15 inches long. September 15, canes short, will require winter protection.

RASPBERRIES.

Turner, twenty plants: June 1, not vigorous. July 1, have better color; in bloom. August 1, new canes long. September 15, no fruit; canes 3 feet tall; very tender.

Miller, twelve plants: June 1, growing slowly. July 1, making slow growth; few bloom. August 1, new canes 18 inches long. September 15, canes 2 feet long, but too tender for freezing weather.

London: June 1, making good growth. July 1, in bloom; growing slowly. August 1, new canes 2 feet long; fruit poor. September 15, 3-foot canes; very tender.

Red Raspberries (common) grown for propagating only: Have done exceedingly well.

GOOSEBERRIES.

Whitesmith, nine plants: June 1, vigorous; in bloom. July 1, average growth 10 inches; no fruit set. August 1, 15 inches growth. September 15, little additional growth; leaves coloring.

Columbus, eight plants: June 1, growing nicely. July 1, average growth 2 inches; very backward; good color. August 1, 5 inches growth. September 15, 10 inches growth; one plant much more vigorous than the others.

Industry, eight plants: June 1, making good start. July 1, good color; making slow growth. August 1, 3 inches growth. September 15, unthrifty. October 1, leaves dropped.

Smith Imperial, five plants: June 1, thrifty start. July 1, 6 inches growth. August 1, very little additional growth. September 15, 1 foot of growth.

Red Jacket, six plants: June 1, vigorous start. July 1, 4 inches growth. August 1, 6 inches growth. September 15, 14 inches growth. October 1, leaves coloring.

Triumph, five plants: June 1, doing well. July 1, good color; very little new growth. August 1, 3 inches growth. September 1, 6 inches growth. October 1, leaves well colored.

English, six plants: June 1, vigorous. July 1, growing nicely; some fruit. August 1, growing slowly. September 15, new growth very short; fruit ripened. October 1, leaves dropping.

Houghton, eighteen plants: June 1, growing nicely; in bloom. July 1, fruit well set; medium size. August 1, 3 inches growth. September 15, fruit ripened; very little additional growth. October 1, leaves dropping.

Champion, thirteen plants: June 1, vigorous, in bloom. July 1, very little fruit set; 3 inches growth. August 1, 5 inches new growth. September 15, 6 inches growth.

STRAWBERRIES.

Bismarck: June 1, growing nicely; in bloom. August 1, fruit ripening; plants vigorous. September 15, many new plants. October 1, young plants in abundance. This is the best variety grown at this station.

Enhance: June 1, in bloom. August 1, no berries set, plants growing nicely. September 15, vigorous new plants.

Michigan: June 1, growing nicely; plants blooming. August 1, no fruit; plants making vigorous growth. September 15, strong new plants; promising.

Saunder: June 1, in bloom. August 1, fruit ripening; poor. September 15, many new plants.

Native: June 1, vigorous growth; in bloom; perfect flowers. August 1, no fruit; Vigorous growth. September 15, new plants in abundance.

ORNAMENTALS.

Caragana arborescens: June 1, doing well. August 1, growing slowly. September 15, plants look well; very short growth.

Caragana microphylla: June 1, not thrifty. August 1, growing slowly. September 15, few plants growing.

Eglantine, nine plants: June 1, doing well. August 1, making vigorous growth. September 15, 18 inches growth; very strong.

Lilac (common), six plants: June 1, growing nicely. August 1, very short new growth. September 15, new growth very short; plants look strong.

Lonicera alba rosea, four plants: June 1, growing nicely. August 1, 6 inches growth. September 15, 8 inches growth; good color.

Lonicera bella albida: June 1, starting nicely. August 1, 4 inches growth. September 15, vigorous strong plants; 10 inches growth. October 1, leaves yet hanging.

Lonicera tatarica rosea: June 1, started well. August 1, 5 inches growth. September 15, plants strong and vigorous; 15 inches growth.

Lonicera tatarica splendens: June 1, thrifty growth. August 1, 6 inches growth. September 15, strong vigorous plants, 15 inches growth. October 1, yet holding the leaves.

Lonicera tatarica, twelve plants: June 1, not thrifty. August 1, making slow growth. September 15, growth very short; not doing well.

Lonicera tatarica grandiflora: June 1, growing nicely. August 1, 3 inches of new growth. September 15, plants strong; 15 inches growth.

Mountain Ash: June I, thrifty. August I, 3 inches growth. September 15, very little additional growth.

Niobe Willow: June 1, doing nicely. August 1. 15 inches growth. September 15, 3 feet of growth. October 1, wood too soft for hard freezing weather.

Rosa rugosa: June 1, doing nicely. August 1. growing slowly. September 15, 8 inches growth; doing very well.

Siberian Sandthorn: June 1, not vigorous. August 1, very little growth. September 15, very backward.

Speer Elderberry, four plants: June 1, just starting growth. August 1, 8 inches growth. September 15, 1 foot of growth. October 1, wood too soft to stand hard freezing weather.

Ural Willow, six plants: June 1, growing vigorously. August 1, 6 inches growth. September 15, 10 inches growth. Cuttings of this have made a strong growth this season.

VEGETABLES.

The season was on the whole quite favorable to the growth of vegetables and the commoner sorts—potatoes, turnips, radishes, lettuce, etc.—did very well. (Pl. VII, fig. 1.) Excellent reports have been received from various parts of the Territory. These are noted under reports from the seed distribution.

At the Sitka Station the soil continues to be so uneven in quality that the experiments we have undertaken with vegetables are not reliable. The soil is acid and requires to be dressed with a still heavier coating of lime than has been so far applied. A summary of the results obtained follows:

BEANS.

Broad Windsor (seed procured from a Seattle seed house): Of this three rows were planted. They all grew splendidly, attained a height of 3 to 4 feet, and were loaded with pods, which were ready for use in the latter part of September, but none of the seed matured.

A few beans of each of many varieties sent to the station from the Department of Agriculture for trial were also planted, but none of them compared to those raised as above stated. Many of them failed to grow and none of them amounted to anything worth mentioning. These varieties were imported from Europe and elsewhere. They were sent out under the following numbers: 2455, 2463, 2465, 2466, 10413, 10414, 10415, 10416, 10431, 10432, 10433, 10435, 10437, 10440, 10443, 10436, 10445, 10434, 10430, 10438, 10418, 10441, 10432.

Wax beans, Pole beans, and Lima beans were not tried, as they have heretofore proved unsuccessful.

BEETS.

Early Egyptian: A short row was planted and did very well, making roots from 3 to 4 inches in diameter.

French White Sugar: A short row of this variety was planted, but it proved a failure.

BROCCOLI.

Large White French: Seed sown in cold frame April 22, producing strong plants, which were set in open ground June 9. Plants set in a small plat of good garden soil developed heads of good size, 6 to 7 inches in diameter. Other plants set in soil not so good developed only very small heads.

BRUSSELS SPROUTS.

Dwarf Improved: Seed sown April 20, with cabbages in flats—that is, shallow boxes in the greenhouse. Only 40 per cent of the seed grew. The plants were set out the first week in June and developed satisfactorily. Brussels sprouts can be grown successfully in the Alaska coast region.

CABBAGE.

All the following varieties were sown in shallow boxes on April 20. These boxes were kept under glass in the greenhouse, which, however, was not heated artificially. They made a good growth. In the middle of May the boxes were set outdoors to harden the plants. This gave us good strong plants by June 1, and they were transplanted between June 1 and 8. One hundred plants of each variety were set out with a view to comparing the different sorts. The experiment was only a partial success, because the soil at the station is not yet in proper condition for culture; although it has been limed it remains acid and is very spotted in character. Early, medium early, and late varieties were represented in about equal numbers.

Extra Early Express: Many plants failed to head. September 1 a few heads were ready for use, but they were small, averaging but 2 pounds in weight.

Early Spring: September 1, a few heads were ready for use. They averaged but 1 pound each, and many plants failed to head.

Early York: This variety did better than either of the two foregoing, though some plants failed to head. By September 1 the heads then ready averaged 3 pounds in weight.

Henderson Early Summer: A larger proportion produced heads, though they were not solid. They were later than those already named and averaged but 2 pounds in weight, though some of the best weighed 4 pounds.

All-Head Early: Only 20 per cent formed heads, but these were good and solid. By November 1 they averaged 3 pounds in weight, and some of the best weighed 5 pounds.

Early Etampes: A French variety. Nearly half of the seed failed to grow. By September 1 a few heads were large enough for use. Some of them weighed 4 pounds each.

Early Large York: Only 30 per cent of the plants headed. By October 15 some of the heads were large enough for use. The best weighed 6 pounds each. Most of them were small but solid.

Early Dwarf Savoy: About 40 per cent of the plants headed. The growth was slow; none were ready for use until November 1, when the largest averaged 3½ pounds.

Early Jersey Wakefield: Of all the early varieties in the tests made at the station up to this time, this is on the whole the most satisfactory. It is a reasonably sure header, although the heads are small. The plants are large and spreading, and one is led to expect larger heads from the size of the leaves. But all things considered, it is a fairly reliable sort. In the present test 70 per cent of the plants produced heads. It is not the earliest sort; none were ready for use until the middle of October, and they continued to grow until November 8. A few heads reached the weight of 5 pounds; 33 heads averaged 3 pounds; the rest were still smaller.

Early Drumhead: Only 40 per cent headed. The growth was slow and they were not ready for use until the last of October. Average weight of heads, 3½ pounds.

Early Dwarf Flat Dutch: A small variety that did not prove to be highly commendable. Its growth was slow; the heads were small, but solid.

All Seasons: About 40 per cent of the plants of this variety produced small heads. The largest weighed 5 pounds.

Premium Drumhead: Only about 30 per cent of this variety produced marketable heads. The largest weighed 2½ pounds. Growth was slow.

Sure Head: Its growth did not justify its name in this case. Less than 30 per cent of the plants formed heads, and these were small and soft.

Short-Stemmed Brunswick: Growth was slow and the heads were small, but they were of even size and quite firm. About 75 per cent of the plants headed.

Fottler Drumhead: Did very poorly throughout. Only 25 per cent of the plants headed. The growth was slow and backward. The best head weighed 3 pounds.

Winningstadt: Has been grown at the station before, and has been more satisfactory in former years than the present season. It produces firm, conical heads of small size. Only 30 per cent of the plants headed.

Charleston or Large Wakefield: Similar to Jersey Wakefield but later and did not do so well as that variety. Average weight of heads, 2 pounds.

Succession: Only a small percentage of plants formed heads and the best of these weighed 3 pounds.

Danish Bald Head: This did not prove a success. Only a small percentage of the plants headed and the heads were very small.

Drumhead Savoy: It was backward and many plants failed to head, and the heads which did grow were not solid.

Large Late Flat Dutch: Though only 30 per cent of the plants headed, this appeared, nevertheless, to be a promising sort. The best head weighed 6 pounds.

As stated at the outset, it would not be fair to pass judgment on this test. The soil is to blame, and it requires time to get the raw peaty soil into condition to produce fair garden crops.

CAULIFLOWER.

The following six varieties were grown: Early London, Early Snowball, Early Favorite, Extra Early Dwarf Erfurt, Early Paris, and Le Normand Short Stem. Like the cabbages, these were sown in flats April 24, kept under glass in a cold greenhouse until the middle of May, and then gradually hardened. Transplanted June 6. In a small patch of good garden soil in town they did well, but those planted on station ground produced but small heads. Those grown on good soil gave results as follows:

Early Snowball: An early and sure header, of even size, and of excellent quality. They were ready in early August.

Extra Early Dwarf Erfurt: A desirable variety but somewhat uncertain. Several plants failed to head.

Early Paris: A fairly good variety.

Early Favorite, Le Normand Short Stem, and Early London: These ranked about together. Early London produced large plants, several of which failed to head and the heads produced were small.

CARROTS.

All the following varieties were planted May 18 and gathered October 9:

French Forcing: This is a short stump-rooted variety producing small roots, but they grew to normal size and can be recommended for early use.

Half Long Scarlet: This variety likewise grew to normal size and was on the whole satisfactory.

Ox Heart: Made a slow growth and yielded but few and small roots. It is not so good as either of the foregoing.

Chantenay: This variety has given good satisfaction at Sitka Station in former years. The present year it did not do so well owing to the soil in which it grew, but it has done well in other parts of Alaska.

Half Long Stump-Rooted: This, too, grew in poor soil, but it made a satisfactory yield and was ready for use in August. It can be recommended for Alaska.

CELERY

Improved White Plume: The past season this variety gave very good satisfaction. It was grown in the cold frame where the soil was rich, but it will also develop normally in the open ground. By September 15 the plants in the cold frame were nearly ready to blanch.

KALE.

Tall Green Scotch and Dwarf German: The plants were started in flats in the same manner as the cabbage plants and transferred to open ground early in June. They developed normally. Kale is one of the crops than can be grown with certainty in Alaska, and when properly cooked there is no more delicious form of greens than Scotch kale. It should be grown in every garden in the Territory.

PARSNIPS.

Hollow Crown: This is a standard variety. In good soil it develops large tender roots. The present year roots 2½ inches in diameter were grown.

PEAS.

Half the pea crop was treated with a commercial inoculating preparation, in order to ascertain the effect, if any, on the yield.

Alaska: Planted May 18. July 1, 2½ feet high, and in bloom by July 15. Pickings were made at various intervals from August 1 to 25. The total yield of pods from a row 60 feet long weighed 21 pounds. The same variety not inoculated developed normally, and there was but little, if any, difference in appearance between those treated and those not treated; but there was a decided difference in yield. A 60-foot row not treated yielded 15¼ pounds.

First and Best: Seed inoculated. Planted May 18. July 1, 2½ feet high and beginning to bloom. They appeared to be a little in advance of Alaska. A 60-foot row yielded 23 pounds between August 1 and 25. Yield of a 60-foot row planted alongside but not treated was but 14 pounds. This and Alaska variety have been very satisfactory at the Sitka Station, and can be recommended for use in Alaska.

Marblehead Mammoth: Planted May 18. July 1, 3 feet high. July 15, a few blossoms showing. August 1, 5 feet high and in full bloom. Pods ready for use August 17. Between this date and September 19 a 60-foot row yielded 42½ pounds. The seed was not inoculated. The pods of this variety were affected by a fungus growth, which did not attack other varieties growing alongside of it. It is a later and larger sort than the two first named, but it also appears to give heavier yields.

Premium Gem: Seed planted May 18. July 1, 2 feet high. Beginning to bloom August 1. Made but poor growth; only a few pods were large enough for use; was almost a failure. The yield of a 60-foot row was 4½ pounds.

POTATOES.

The following varieties were grown: Extra Early Ohio, Early Ohio, Freeman, Burbank, Hamilton Early, Extra Early Triumph, Banner, Lincoln, Early Harvest, Bovee, Red River White Ohio, White Mammoth, Pat's Choice, Extra Early Pioneer, Early Michigan, Vornehm, Vigensia, Irish Cobbler, Ohio Junior, White Beauty, Early Andes, Garfield, Extra Early, Carman No. 3, White Kenai, and Red Kenai.

Most of these were grown on a very small scale. The seed was procured by the pound, and only from 1 to 4 pounds were planted, and the yields of these small plats can not be compared with any profit. Those grown on a larger scale from seed raised at the station the previous year were Freeman, Garfield, Burbank, White Kenai, and Red Kenai. Of these the Freeman was by far the best, one-nineteenth of an acre yielding 1,446 pounds, or at the rate of 550 bushels to the acre, and 94 per cent of the crop was marketable.

Burbank: Yielded at the rate of 288 bushels per acre, and 86 per cent of the crop was marketable.

Garfield: Yielded at the rate of 54 bushels to the acre, of which 80 per cent was marketable.

White Kenai: Yielded at the rate of 117 bushels per acre, of which 65 per cent was marketable.

Red Kenai: Yielded at the rate of 89 bushels to the acre, of which 76 per cent was marketable.

This great difference in yield is partly due to inequalities in the soil, a condition we have not yet been able to rectify, but in the main the difference is due to the varieties. Up to this time the Freeman is the best potato grown at the station. It is medium early, white, oblong, of medium size and quite uniform, shallow eyes, and excellent quality, being dry and mealy when boiled. The two varieties—named, respectively, the White and Red Kenai—were obtained from the village of Kenai, on Cook Inlet, where it was claimed that they had been grown by the Russian settlers for at least fifty years. These potatoes have no special merit, except the fact that they have been thoroughly acclimated, but they are not early, nor are they of first quality.

It is to be noted that seed potatoes imported from the States usually do not do well the first year. They do not compare in yield or vigor with potatoes of the same varieties raised from Alaska-grown seed. This fact has been observed also by many settlers, who have commented upon it. The varieties here named will be grown again next year from the present crop of seed, and it will then be possible to make a better estimate of their comparative value.

KOHL-RABI.

Planted in open ground May 15. By September they gave promise of a fair crop, and October 8 we gathered 124 pounds of marketable roots from 280 feet of row, which was a very small yield.

RUTA-BAGA.

Purple Top Yellow Swede: Seed planted in open ground May 15. October 8, 210 pounds of marketable roots were gathered from 280 feet of row.

TURNIPS.

No. 1678, Imported Finnish Seed: Seed sown May 15. The crop yielded 160 pounds of marketable roots from 140 feet of row. This is a small white turnip of good quality. No. 6176, Imported Finnish Seed: Seed sown May 15. Yield, 240 pounds of marketable roots from 120 feet of row. This is a small yellow turnip of very fine quality.

WORK AT THE COPPER CENTER STATION.

OUTLINE OF OPERATIONS.

Since the last report little has been done in the way of building, except the addition of a shed, 14 by 30 feet in size, on the south side of the barn, which is ready for the roof; also a frost-proof root cellar is nearing completion.

Having no help from October until February, when the freighting season opened, the superintendent spent his time in making the cabin (Pl. IV, fig. 1) and barn a little more comfortable for cold weather, whipsawing some lumber, building a hay press, making a roll-top office desk, baling and freighting 5 tons of native hay from Willow Creek to the station, and freighting 1,900 feet of lumber 20 miles down the Klutena River.

The frost being sufficiently out of the ground, stirring the soil was begun April 25. The first plats were seeded May 9, as 25 acres were then ready for the drill. The last seeding was done May 25. Thirty acres were seeded to the various grains, 3 acres of which were seeded to awnless brome grass (*Bromus inermis*).

After the seeding was done attention was given to clearing and breaking 4 acres of low wet ground for the purpose of seeding it to timothy and other grasses. Seven acres of new ground which had already been broken, with the 3 acres broken later, make 14 acres of new ground broken this season. There are now 36 acres of ground broken and about 5 acres cleared, which could not be broken until the ground became too dry. The 4 acres broken for grasses could not be got in shape in reasonable time for seeding, and it was thought best to defer seeding till next spring, and at the same time sow oats or some kind of grain with the grass seed. Clearings of last year had to be fenced, and it was also due time to fence off the pasture lands, as travel is rapidly increasing from year to year over this trail. Enough stock passed here this season to graze off our entire pasture in a single day; the last herd of beef cattle passing numbered 76 head.

One mile of barbed-wire fence was built, two-thirds of a mile of stake-and-rider fence, and a picket fence inclosing about 1 acre around the cabin. The yard was then cleared of moss, plowed, graded, and laid out with 5-foot walks to be graveled and the remainder seeded to grass, leaving a good-sized kitchen garden on one side and a small grass plat in the rear.

WEATHER CONDITIONS.

This season has varied somewhat from either of the two previous years of our field operations. The precipitation has been so light that crops made very short growth. Even the wild grasses in open places were seen to be withering in midsummer and did not make their usual growth.

The snowfall was also very light last winter, amounting to but 25⅝ inches, making but 1.64 inches actual precipitation of melted snow. The rainfall from the last snow until September 1 was but 3.05 inches, and this was distributed in light showers, usually just laying the dust and doing crops little good.

Other conditions remained very favorable to growing crops until August 1, when cool, damp, cloudy weather set in. From this time on most of the grains made very little advance toward ripening. August 14 the temperature fell to 26° F. on the main bench and 23° F. on the upper bench, seriously injuring the crops. This frost was followed by killing frosts on August 19, 21, and 24, the coldest being 20° F. on the lower bench and 16° F. on the upper bench.

CULTURE WORK AND FIELD NOTES.

It is becoming apparent that grain growing is not to be the chief industry in this section of the Copper Valley, owing to the early frosts, and especially those through the month of August. However, under usual conditions, any amount of rough feed can be grown. Crops were light this year owing to the lack of rain.

It has been thoroughly demonstrated for the third time that new land broken and seeded the same year does little more than return the seed sown, and even this is difficult to save on account of short growth. New land, however, may be made to produce heavy crops by using some fertilizer. Experiments this year, in almost every instance, proved that new ground just broken and fertilized with guano at the rate of 500 or 600 pounds per acre—the greater amount giving the best results—produced from 50 to 90 per cent better crops than where no fertilizer was used. Where brush or logs were burned in some quantity, the result was about the same as where the fertilizer was used. Third-year ground also responded to fertilizers, but of course not to so marked a degree. Wherever the fertilizer was used the growth was more vigorous and the crops

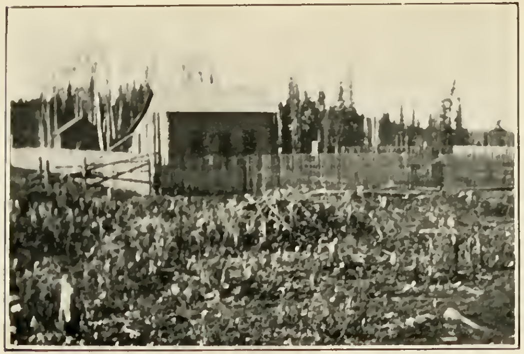


FIG. 1.—STATION BUILDING.

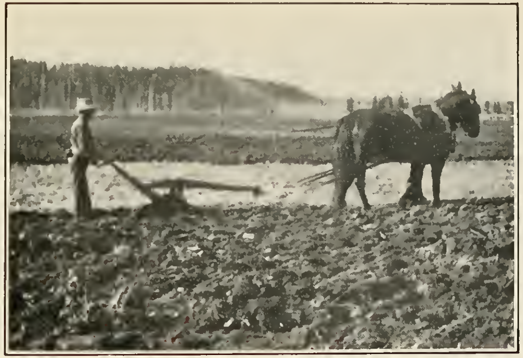


FIG. 2.—FALL PLOWING.

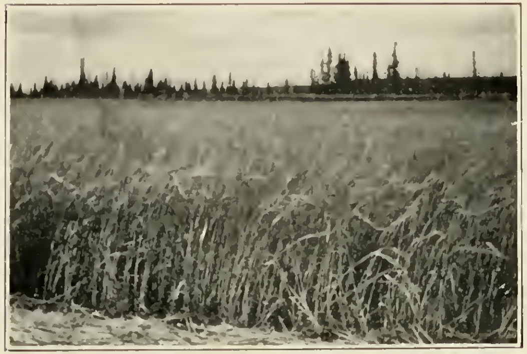


FIG. 3.—BARLEY FIELD.

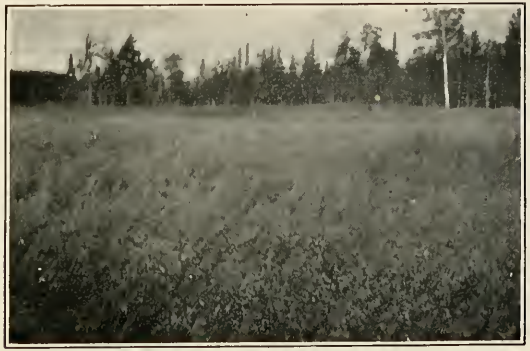


FIG. 4.—SWEDISH SELECT OATS.

VIEWS AT THE COPPER CENTER STATION.

had a better color from the first, and invariably the heads were much larger and the growth more uniform on both old and new ground. On these fertilized plats and burned spots the grain stood well, and this dry season I counted as many as 18 large heads from one grain of barley and 26 heads from one grain of oats where the seed was scattered sparingly. New ground broken and let lie to the weather one year gave very good returns even in this dry year. (Pl. IV, fig. 2.) It produced fully 1 ton of hay per acre, while third-year ground alongside the summer-fallowed new ground did not produce more than half that amount. It should be said, however, that this summer fallow was very rich sod and more capable of holding moisture than the old ground.

For convenience in this report the several tracts seeded are designated as follows:

Tract A, third-year ground, used last season as the main culture tract. The soil is rather light and dry.

Tract B, third-year ground on the same bench, but heavier soil.

Tract C, new ground on a bench probably 150 feet higher than tracts A and B. This soil is somewhat heavier than the majority of that on the lower bench, having more of a clay subsoil.

Tract D represents the large field plats on either bench.

On tracts A, B, and C half of each plat or variety was fertilized at the time of seeding with guano, at the rate of about 500 pounds per acre. Tract A was laid out exactly as last year in order to refertilize a portion of each plat, leaving a portion of last season's fertilizing undisturbed, and fertilizing half of the ground not fertilized last year, leaving the remainder unfertilized from the beginning. The fertilizer used was the same kind and quantity each year. There being no visible results from the fertilizing of last year on the present crop, there is no mention of that fertilizing in my notes on this year's crop.

Tracts A and C were seeded with a small hand drill. Tract B was seeded in open drills by hand and covered with a hand rake. Tract D was seeded with a horse drill unless otherwise mentioned. In tract D the summer fallow mentioned is a deep black soil on the willow ground, broken in the fall of 1903 and not seeded last year.

The results of the fertilizer experiment on tract C were in some measure obscured, owing to the fact that the tract was new ground broken before the small culture tract was selected, and unfortunately a portion of the tract had considerable brush burned on it, the effect of which was in evidence as soon as the grains were up a few days. Therefore, the unfertilized portions gave much better results than they otherwise would have done, judging from the growth over the main field.

WHEAT.

Kharkov Winter: Sown August 3, 1904. Seed germinated very quickly, making a good stand, and covered the ground with the vesture of an eastern wheat field by the end of September. Spring growth started early in May. The fall growth was nearly all dead, but by June 1 the drills were again thickly covered and some stood 5 or 6 inches high. A few spots, however, were suffering from drought and winter injury. June 15, 8 to 10 inches of height had been gained, and the grain looked well. July 1, 16 to 18 inches high; some heads showing; the soil getting very dry. July 15, grain 20 to 38 inches high; the blooms falling and the grain forming. July 28, the grain well filled and nearly in the milk. August 14, grain in dough and beginning to harden when injured by a heavy frost. The straw was turning and ripened very rapidly after the frost. Several severe frosts followed within a few days. This grain was cut for thrashing, as it is thought some grains will grow.

Padui No. 9129: A bearded variety of winter wheat, seeded July 16, 1904. It acted about the same as the Kharkov, except that much of this variety was winterkilled, and it was not quite so far advanced when injured by the same frost.

Romanow: Sown in tract A, May 9. The seed germinated rather slowly, and probably only 75 per cent came up. May 24, coming up. July 1, that on fertilized ground was 16 to 17 inches high; that on unfertilized, 12 inches high. August 14, spoiled by frost. No seed matured. The fertilized ground produced fully 25 per cent more straw than the unfertilized.

Saskatchewan Fife: Sown in four different plats.

Tract A.—Seeded May 10. May 23, coming up. July 28, on fertilized portion averaged 28 inches high, best 30 inches high; on unfertilized, 18 inches high; grain two-thirds filled. August 14, frosts spoiled the grain and no seed matured. This variety, as with all the wheats in tract A, was sufficiently matured for good hay by August 30, and when cut cured very quickly.

Tract B.—Seeded May 25. June 3, coming up. July 29, that on fertilized ground averaged 30 inches high; best, 36 inches high; that on unfertilized ground averaged 24 inches high. August 14, grain about filled when spoiled by frost.

Tract C.—Seeded May 23. June 1, coming up. July 28, on fertilized portion, averaged 38 inches; best, 40 inches; on unfertilized, averaged 20 inches. August 14, frost spoiled the grain when about filled. September 1, cut for hay. The fertilized plat yielded about 50 per cent more straw than the unfertilized.

Tract D.—Seeded May 10, with horse drill on both old ground and summer fallow of the first seeding. Coming up May 23. July 28, 24 inches high on the old ground and the grain a little more than half filled, heads rather small; on the summer fallow, straw very thick on the ground, standing 38 inches high and about heading, grain just forming. August 14, frost spoiled the grain. At that date, most of the grain on old ground was in the dough.

Velvet Chaff Blue Stem: This variety was also sown in four different tracts.

Tract A.—Seeded May 10. Coming up May 23. July 28, best 38 inches high, average 34 inches on the fertilized plat, grain about half filled; on unfertilized plat, average 24 inches high, heads smaller, and the grain not so much filled. August 14, frost spoiled the grain. Would have ripened in a few days of favorable weather.

Tract B.—Seeded May 25. Coming up June 2. July 29, the best was 36 inches high, the average 33 inches, on the plat fertilized; on the unfertilized, average height about 20 inches, grain just forming. August 14, the grain was about filled when spoiled by frost.

Tract C.—Seeded May 23. Coming up June 1. July 28, on fertilized ground, averaged 36 inches high, best 40 inches high; on unfertilized, averaged about 26 inches, grain just forming. August 14, frosts spoiled the grain when about filled.

Tract D.—Seeded May 10 on both old ground and summer fallow of the first seeding. Coming up May 23. July 28, 18 to 24 inches high on the old ground, and the grain about half filled, heads small; 30 to 40 inches high on the summer fallow and the grain nearly one-third filled. Frost spoiled the grain August 14. The grain on the old ground was well filled and in the dough. That on the summer fallow was several days later, the growth rank and yet green.

Early Riga: This variety was sown May 10 only in tract A. Coming up May 23. July 28, the grain was well filled and about in the milk. August 14, the grain was in the dough when spoiled by a heavy frost. A few heads were nearly matured.

Romanow, No. 8892: This variety was seeded in four different tracts.

Tract A.—Seeded May 10. Coming up May 24. July 28, the best was 31 inches high, averaging about 30 inches on fertilized plat, grain being well filled and nearly in the milk; on unfertilized, averaged about 24 inches, and a day or two later in filling. August 14, spoiled by frost.

Tract B.—Seeded May 25. Coming up June 3. July 29, the best was 42 inches high, averaging about 40 inches on the fertilized plat, grain half filled; on unfertilized, averaged about 28 inches high, grain one-third filled. August 14, spoiled by frost.

Tract C.—Seeded May 23. Coming up June 1. July 28, best 44 inches high, with an average of 42 inches on the fertilized plat; on the unfertilized, averaged about 23 inches high. The grain was one-third filled. August 14, spoiled by frost.

Tract D.—Seeded May 10 on old ground and summer fallow of the first seeding. Coming up May 23. July 28, 18 to 24 inches high on the old ground, grain about half filled; on the summer fallow, 30 to 40 inches high, headed, and the grain one-third filled. August 14, the grain on the old ground was in the dough and well filled when spoiled by frost; that on the summer fallow was some days later.

Romanow, seed of first importation: A small amount of this seed was held over from last year's seeding. Sown on tract A May 10. Coming up May 25. July 28, 35 to 38 inches high; grain about two-thirds filled; heads of fair size and quite uniform. August 14, grain well filled and in dough when spoiled by frost.

Romanow, imported seed: Sown on tract A May 10. Coming up May 25. July 28, 30 inches high; grain about two-thirds filled. August 14, the grain was well filled and in the dough when spoiled by frost.

Romanow, Sitka Experiment Station seed: Two plats of this variety were sown.

Tract B.—Seeded May 25. Coming up June 3. July 28, on the fertilized portion the best was 40 inches high, with an average height of 36 inches, and the grain was one-third filled; on the unfertilized portion average height about 28 inches, and the grain was filling a little later. August 14, spoiled by frost.

Tract C.—Seeded May 23. Coming up June 2. July 28, on the fertilized ground the best was 38 inches high, with an average height of 36 inches; grain about filled; average height on the unfertilized, 27 inches, and grain filling a day or two later. August 14, spoiled by frost.

Stanley: This variety was sown in tract A only on May 10. Coming up May 23. July 28, on the portions fertilized the best was 34 inches high, with an average height of 33 inches, grain being about three-fourths filled; on the unfertilized, average height, 24 inches, filling at about the same stage. August 14, spoiled by frost.

Ladoga: This variety was sown in tract A only on May 10. Coming up May 22. July 28, on the fertilized portion, the best was 28 inches high, with an average height of 26 inches; on the unfertilized, average height, 20 inches. This variety was so far advanced that some heads matured fair grain.

Preston: This variety was sown in tract A only on May 10. Coming up May 24. July 28, on the portion fertilized, the best was 34 inches high, with an average height of 32 inches; average height on the unfertilized, 26 inches. August 14, the grain was well filled and in the dough when spoiled by a frost.

Ebert: Sown in tract A May 10. Coming up May 24. July 28, the average height on the portion fertilized was 30 inches, the grain being about two-thirds filled; on the unfertilized, average height about 22 inches. August 14, grain just in the dough when spoiled by frost.

Plumper: This variety was sown on 3 tracts, A, B, and C.

Tract A.—Sown May 10. Coming up May 25. July 28, on the portion fertilized, the best was 30 inches high and the average 28 inches, grain more than two-thirds filled; on unfertilized, average about 23 inches high, grain filling a little later. August 14, grain in the dough when spoiled by a frost.

Tract B.—Seeded May 25. Coming up June 3. July 29, the fertilized portion averaged 36 inches high, grain one-third filled; the unfertilized averaged 26 inches high, grain filling a little later. August 14, spoiled by a frost.

Tract C.—Seeded May 23. Coming up June 2. July 28, that on fertilized ground averaged 38 inches, the best 40 inches; that on unfertilized averaged 26 inches, grain about half filled. Spoiled by frost.

Glyndon No. 661: This variety was also sown on three tracts.

Tract A.—Sown May 10. Coming up May 25. July 28, that on fertilized ground averaged 30 inches high, best 32 inches high, grain half filled; average height on unfertilized ground was about 27 inches, grain one-third filled. August 14, the grain was in the dough and spoiled by a frost.

Tract B.—Seeded May 25. Coming up June 3. July 29, on fertilized plat averaged 35 inches high, best 38 inches high; on unfertilized averaged 24 inches high, grain just forming. August 14, frost spoiled the grain.

Tract C.—Seeded May 23. Coming up June 2. July 28, the best 36 inches high on the fertilized portions, average height 33 inches; on the unfertilized, average 18 inches high, headed and blooming. Spoiled by frost when about filled.

Harold: Sown in three different tracts, as follows:

Tract A.—Seeded May 10. Coming up May 24. July 28, average 27 inches high on the portions fertilized; on the unfertilized averaged 20 inches high. August 14, grain injured by frost, but some heads were so far advanced that the grain seemed to have escaped without injury. The crop was cut for seed.

Tract B.—Seeded May 25. Coming up June 3. July 29, that on fertilized portions averaged 34 inches high, that on unfertilized ground averaged 26 inches high. Grain one-fourth filled when killed by frost.

Tract C.—Seeded May 23. Coming up June 2. July 28, that sown on fertilized ground averaged 43 inches high, on unfertilized 26 inches high; grain just forming on both plats. Spoiled by frost.

Kubanka: This variety was sown in two tracts.

Tract B.—Seeded May 25. Coming up June 4. July 29, fertilized 34 to 40 inches high, grain just forming; unfertilized 20 to 26 inches high; grain the same. Spoiled by frost

Tract C.—Seeded May 23. Coming up June 2. July 28, fertilized 40 to 46 inches high; unfertilized 20 to 24 inches high; grain just forming in both. No seed matured.

Russian wheat, No. 2955: Sown on tract C May 23. This seed was old and germinated very slowly. June 15, a small percentage was up 3 inches high. July 28, that on fertilized ground was 20 to 30 inches high; on unfertilized 12 to 18 inches high; grain just forming in both. No seed matured.

Of all the wheats tried this year Ladoga and Harold were the furthest advanced when the first killing frost came. These two varieties matured many heads sufficiently for making flour, and a part of the seed will grow. But even of these varieties the greater portion was spoiled by frost. Next to these was Ebert, with many heads almost matured. Plumper, Stanley, Early Riga, and Roumanian were next, with many heads nearly ripe. These were all on tract A, the earliest seeded.

BUCKWHEAT.

Silver Hull: Home-grown seed from 1903 crop was sown on tracts B and C with the following results:

Tract B.—Sown May 25. Coming up June 3. July 15, excellent color and filled with bloom. The fertilized portion was slightly injured July 19 by frost, the top leaves being killed. Nothing else on the station showed any effects of this frost. The minimum temperature registered was 34° F. on that date. July 29, partially recovered injury from the frost and was in full bloom. August 14, killed to the ground by frost; some seed had nearly matured.

Tract C.—Seeded from the same seed May 23. Coming up June 3. July 28, about the same on both plats, being 20 to 24 inches high, covered with bloom. August 14, killed to the ground by frost; some of the grain was almost matured.

RYE.

Schlansted Winter: Sown July 16, 1904. Did not come up. The seed evidently was old.

Excelsior Winter: Sown July 16, 1904. Came up quickly and covered the ground well by winter. June 1, jointing; some stalks 8 to 9 inches high; a few spots showed winter injury. July 15, grain about half filled, straw beginning to ripen. July 28, grain well filled and in the dough. August 14, grain injured by frost; some grain seemed matured, and the crop was cut for seed.

Another winter variety (not named): Seeded at the same time behaved about the same as Excelsior Winter. June 15, 18 inches high, heads about showing. July 28, grain well filled and in the dough. August 14, grain injured by frost. Some grain seemed matured, and the crop was cut for seed.

Spring rye, True Stock: Seeded in Tract D May 25. Coming up June 3. July 29, that on fertilized ground, 40 to 44 inches high, grain one-third filled; on unfertilized, 36 to 40 inches high, grain filling a day or two later. August 14, the grain was about filled when spoiled by frost.

Another plant of this same variety was seeded the same day, farther up the flat and near the winter wheat. It behaved about the same and yielded a good crop of hay. It was reasonably thick on the ground and stood from 3 to 4 feet high alongside of oats sown some days earlier, which stood but 12 to 16 inches high. The point of interest rests in the fact that the spring rye yielded fully two-thirds more forage than the oats under like conditions, the soil being the same.

BARLEY.

Champion: This variety was tried on three different tracts with the following results:

Tract A.—Seeded May 11. Coming up May 24. July 28, on the fertilized ground, 24 to 30 inches high, grain in the dough, straw golden color; on the unfertilized, 16 to 20 inches high, grain well filled, but not so far advanced by some days. August 14, grain hardening, frost injured it some. The crop was thrashed for seed (Pl. IV, fig. 3).

Tract B.—Seeded May 25. Coming up June 3. July 29, on fertilized ground, 24 to 33 inches high; on unfertilized, 12 to 18 inches high; grain one-third filled in both plats. Spoiled by frost.

Tract C.—Seeded May 23. Coming up May 31. July 28, on fertilized portion, 40 to 48 inches high; on unfertilized, 24 to 34 inches high; grain half filled in both plats, straw turning. August 14, grain spoiled by frost.

Hanna Two-Row (fall); This variety was tested on Tracts A and D.

Tract A.—Sown May 11. Coming up May 24 July 28, on the fertilized plat, grain well filled and nearly in the dough, straw turning; on the unfertilized, 16 to 18 inches high, grain about filled, straw not turning. August 14, all in the dough, but most advanced on the fertilized plat; damaged by frost.

Tract D, on lower bench.—Second-year ground; seeded May 13. Coming up May 25. July 28, 18 to 24 inches high, grain nearly filled. August 14, grain spoiled by frost.

Tract D, on the upper bench.—New ground, seeded broadcast May 23. Coming up June 1. July 28, 40 to 44 inches high, grain half filled. August 14, grain spoiled by frost; straw thick on the ground and matured sufficiently for good hay August 22.

Chevalier (beardless): This variety was tried on tracts A, B, and C.

Tract A.—Seeded May 11. Coming up May 24. July 28, on the fertilized part, 18 to 24 inches high, grain in the dough and straw semigolden; on the unfertilized, 10 to 14 inches high, grain and straw ripening a little later. Grain damaged by frosts and shriveled some.

Tract B.—Seeded May 25. Coming up June 3. July 29, on fertilized portion, 20 to 28 inches high, grain half filled; on unfertilized, 12 to 20 inches high, grain about the same. Grain spoiled by frost.

Tract C.—Seeded May 23. Coming up June 1. July 28, that on fertilized ground, 30 inches high, grain half filled; on unfertilized, 20 to 26 inches high, grain filled about the same. August 14, grain spoiled by frost.

Odessa: This variety was sown on three tracts with the following results:

Tract A.—Seeded May 11. Coming up May 24. July 28, on the fertilized portion, 24 to 28 inches high, grain well filled and in the dough, straw turning fast; on the unfertilized, 14 to 20 inches high, grain a little later. August 14, frost damaged the grain, causing it to shrivel some.

Tract B.—Seeded May 25. Coming up June 2. July 29, on the fertilized plat, 27 to 33 inches high, grain half filled; on the unfertilized, 18 to 27 inches high, grain one-third filled. August 14, spoiled by frost.

Tract C.—Seeded May 23. Coming up May 31. July 28, on fertilized ground, 36 inches high, grain nearly filled; on unfertilized, 30 to 35 inches high, grain the same. August 14, grain spoiled by frost.

Black Hulless: This variety was also tried on three different tracts.

Tract A.—Seeded May 12. Coming up May 24. July 28, fertilized, 20 to 25 inches high, grain well filled in the dough, straw nearly golden; unfertilized, 15 to 19 inches high, grain filled about three days later. Damaged by frost.

Tract B.—Seeded May 25. Coming up June 2. July 29, on fertilized ground, 30 to 32 inches high; on unfertilized, 18 to 24 inches high; grain in both plats about three-fourths filled. Spoiled by frost.

Tract C.—Seeded May 23. Coming up May 31. July 28, that on the fertilized portion was 30 to 36 inches high; on unfertilized, 20 to 30 inches high; grain about filled in both plats. August 14, the grain was damaged by frost. It was thrashed and sacked with that from tract A.

Sisolsk: This seed was sown for testing on three tracts.

Tract A.—Seeded May 12. June 1, none showing. July 1, a small percentage came and was 15 to 16 inches high. July 28, on fertilized ground, 25 to 32 inches high; on unfertilized not quite so high; grain one-fourth filled in both plats. Damaged by frost.

Tract D.—Seeded May 25. Coming up June 3. July 29, on the fertilized portion, 20 to 27 inches high, grain one-third filled; on the unfertilized, 14 to 20 inches high, grain filling a little later. August 14, grain was spoiled.

Tract C.—Seeded May 23. Coming up June 2. July 28, that on the fertilized area was 36 to 38 inches high, grain about half filled; that on unfertilized ground, 20 to 30 inches high, grain filling a little later. Grain spoiled by frost.

Lapland: Sown on tract A, May 12. Coming up May 25. July 28, 25 to 30 inches high, grain well filled, and nearly in the dough; straw turning. August 14, almost ripe. The grain shriveled some.

Primus No. 10586: This was sown on two tracts with the following results:

Tract A.—Seeded May 12. Coming up May 25. July 28, on fertilized portion, 25 to 28 inches high, grain well filled and in the dough; on unfertilized, 20 to 22 inches high, grain filled a little later; straw ripening fast on both plats. August 14, grain damaged by frost.

Tract B.—Seeded May 25. Coming up June 3. July 29, on fertilized ground, 24 to 33 inches high, about all headed, grain one-fourth filled; on unfertilized, 18 to 24 inches high, grain filling a little later. August 14, grain spoiled by frost.

Manchuria: This variety was tested on all four tracts.

Tract A.—Seeded May 12. Coming up May 25. July 28, where fertilizer was applied it was 26 to 30 inches high, grain well filled and in the dough, straw turning yellow; on unfertilized portion, 14 to 18 inches high, grain filled a little later. Frost caused the grain to shrivel some.

Tract B.—Seeded May 25. Coming up June 3. July 29 on the fertilized area 26 to 32 inches high, grain about half filled; on the unfertilized, 12 to 18 inches high, grain filled a little later. Grain spoiled by frost.

Tract C.—Seeded May 23. Coming up June 1. July 28, where fertilized, 36 to 40 inches high, grain half filled; where unfertilized, 24 to 34 inches high, grain one-third filled. Spoiled by frost.

Tract D.—Seeded May 12 on new and second-year ground. Coming up May 24. July 28, 18 to 32 inches high, grain about filled, straw ripening fast. August 14, grain spoiled by frost.

Hanna, No. 9133: This variety was also sown on all four tracts.

Tract A.—Seeded May 12. Coming up May 24. July 28 where fertilized was 24 to 28 inches high, grain well filled and in the dough, straw nearly golden; where unfertilized, 16 to 18 inches high, grain filled a little later. Grain damaged by frost; shriveled some.

Tract B.—Seeded May 25. Coming up June 2. July 29 on the fertilized portion 20 to 32 inches high, grain about half filled; on the unfertilized, 18 to 25 inches high, grain one-third filled. Spoiled by frost.

Tract C.—Seeded May 25. Coming up June 1. July 28, where fertilized, 36 inches high; where unfertilized, 24 to 30 inches high; grain about one-half filled in both plats. Spoiled by frost.

Tract D.—Seeded May 11, broadcast on summer fallow and newly broken ground. Coming up May 25. July 28, 26 to 30 inches high, grain about half filled, heads good size, uniform; on burned spots, 32 to 40 inches high, grain filling a little earlier. August 14 grain spoiled by frost.

Mansbury: This seed was sown on each of the four tracts.

Tract A.—Seeded May 12. Coming up May 26. July 28, where fertilized, 24 to 30 inches high, heads large, uniform, grain nearly filled; where unfertilized, 22 to 26 inches high, grain filling a little in advance. August 14 grain in the dough but damaged somewhat by frost.

Tract D.—Seeded May 25. Coming up June 3. July 29, on fertilized ground, 30 to 34 inches high, grain one-fourth filled; on unfertilized, 18 to 23 inches high, grain filling a day or two later. Spoiled by frost.

Tract C.—Seeded May 23. Coming up June 1. July 28 on the fertilized portion 36 to 41 inches high; on the unfertilized, 20 to 24 inches; grain one-fourth filled in both plats. Grain spoiled by frost.

Tract D, lower bench.—Seeded May 9 and 10 on old and new ground. A part of this new ground was fertilized with guano at the rate of 500 to 600 pounds per acre, also a part with new stable manure, covering the ground liberally. The season proved too dry for the stable manure to show any effect. Coming up May 23. July 28 on old ground 20 to 36 inches, grain nearly filled; on guano plat averaged nearly 36 inches high, thick on the ground, grain filled and in the dough, straw nearly golden color; on burned spots 24 to 36 inches high, nearly as good as on guano plats and quite as far advanced; remainder very short and quite green. Somewhat damaged by the frost. The spots furthest advanced were thrashed for seed.

Trooper: Seed of this variety was sown on tracts A, B, and C.

Tract A.—Seeded May 12. Coming up May 25. July 28 on fertilized portion 25 to 28 inches high, grain well filled and nearly in the dough, straw turning; on the unfertilized, 14 to 20 inches high, grain filled a little later. Damaged by frost.

Tract B.—Seeded May 25. Coming up June 3. July 29 on fertilized area 24 to 32 inches high, grain one-third filled; on unfertilized, 12 to 18 inches high, grain filling a little later. Spoiled by frost.

Tract C.—Seeded May 23. Coming up May 31. July 28 on fertilized area 36 to 42 inches high, grain nearly half filled; on unfertilized, 24 to 32 inches high, grain filling about the same.

Royal: Sown on tract C May 23. Coming up June 1. July 28 on the fertilized plat 30 to 35 inches high; on the unfertilized, 24 to 30 inches high; grain two-thirds filled in both plats. Spoiled by frost.

Several of the barleys in tract A were almost ripe when the first killing frost came, August 14, which caused them to shrivel some. Champion was the furthest advanced, closely followed by Chevalier, Odessa, Black Hulless, Manchuria, Manshury, Hanna No. 9133, and Primus No. 10586. The several varieties in this tract were thrashed to ascertain what part, if any, of the seed will grow. The later sowings were unquestionably lost and were therefore cut for feed. The unfavorable weather from August 1 prevented both the wheats and barleys from hardening.

OATS.

Finnish Black (Rampart Experiment Station Seed): This variety was tested on each of the four tracts.

Tract A.—Seeded May 12. Coming up May 25. July 28 where fertilized 30 to 36 inches high, grain well filled, in the milk, straw turning yellow; where unfertilized, 18 to 22 inches high, grain filling a little later. August 14 grain hardening. Harvested for seed August 30, no visible injury from frost (Pl. V, fig. 1).

Tract B.—Seeded May 25. Coming up June 4. July 29 on fertilized ground 30 to 38 inches high, grain one-third filled; on unfertilized, 18 to 20 inches high, grain nearly half filled. August 14, frost damaged the crop, most of the grain shriveled.

Tract C.—Seeded May 23. Coming up June 2. July 28, on the fertilized plat, 40 to 42 inches high, grain about formed; on the unfertilized, 24 to 30 inches high, grain about the same. Frost of August 14 damaged the crop somewhat.

Tract D (Sitka Experiment Station seed).—Seeded on lower bench May 9, third-year ground. Coming up May 23. July 28, 20 to 30 inches high, grain well filled and nearly in the milk. August 14, frost damaged a small per centage. The crop was thrashed for seed.

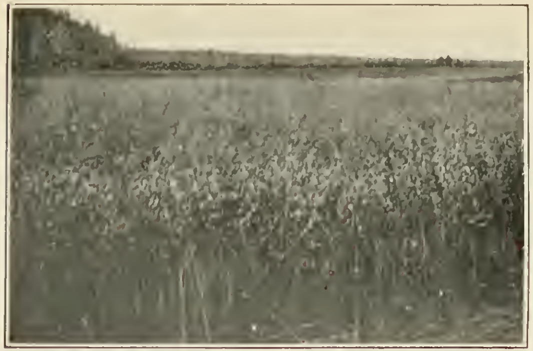


FIG. 1.—FINNISH BLACK OATS.

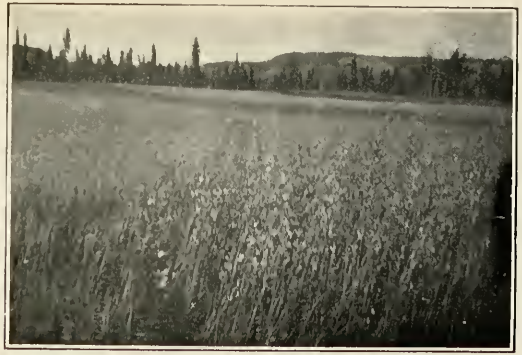


FIG. 2.—BURT EXTRA EARLY OATS.

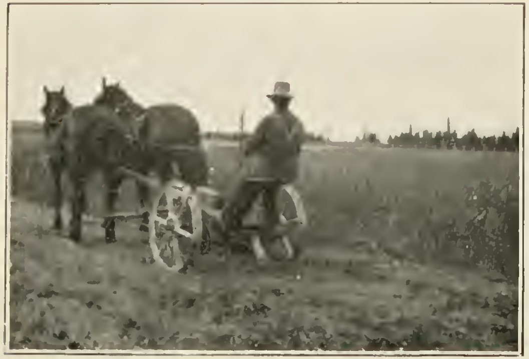


FIG. 3.—CUTTING GRAIN.

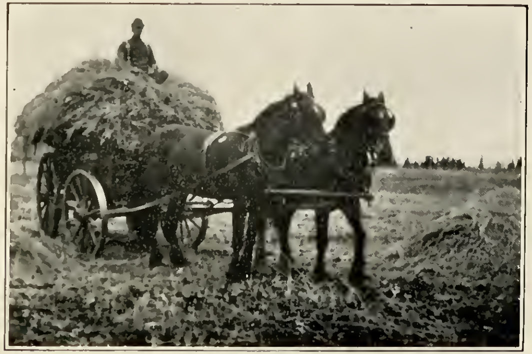


FIG. 4.—HAULING GRAIN HAY.

VIEWS AT THE COPPER CENTER STATION.

Two other field plats of these oats were seeded from home-grown seed saved from 1904 crop; only about 15 per cent grew, the seed having been exposed to severe frosts when ripening.

Banner: Seed of this variety was sown on tracts A, B, C, and D.

Tract A.—Seeded May 12. Coming up May 23. July 28, on the fertilized part, 20 to 24 inches high, grain filled and nearly in the milk; on the unfertilized, 12 to 15 inches, grain filled a little later. August 14, grain hardening; seems to have escaped the frost with little visible damage. Harvested for seed August 30.

Tract B.—Seeded May 25. Coming up June 3. July 29, on fertilized area, 30 to 34 inches high, grain just forming; on the unfertilized, 12 to 18 inches high, grain forming a little earlier. Frost of August 14 caused some of the grain to shrivel.

Tract D.—Seeded May 11, on third-year ground, also on summer fallow of the first seeding, lower bench. Coming up May 22. July 28, on old ground, 10 to 18 inches high, grain in the milk; on summer fallow, 24 to 30 inches high, grain half filled. This sowing covered a tract of new ground, and at this date, on burned spots, it was 40 to 41 inches high, with the grain half filled. August 14, frost spoiled the greater portion. It was much the furthest advanced on the driest and poorest soil, and there only a small percentage showed any injury. This portion of the tract was harvested and thrashed for seed.

Russian No. 2800: Sown on each of the four tracts.

Tract A.—Seeded May 12. Coming up May 25. July 28, where fertilized, 25 to 28 inches high; where unfertilized, 16 to 19 inches high; grain well filled and in the milk. Straw turning in both plats. August 14, grain hardening. The grain was thrashed for seed, as the frost did not seem to hurt it.

Tract B.—Seeded May 25. Coming up June 3. July 28, where fertilized, 30 to 36 inches high, headed, grain one-third filled; where unfertilized, 14 to 18 inches high, grain filling a day or two later. August 14, frost damaged the grain; much of it shriveled.

Tract C.—Seeded May 23. Coming up May 31. July 28, on the fertilized part, 35 to 40 inches high, grain well formed; on the unfertilized, 25 to 35 inches high, grain one-fourth filled. Damaged by frost; the straw cut for feed.

Tract D.—Seeded May 9. Coming up May 22. July 28, 16 to 32 inches, grain well filled and much of it in the milk; straw turning. August 21, cut for seed, a small percentage shriveled by frost August 14.

Tartar King: Sowings made on the four tracts.

Tract A.—Seeded May 12. Coming up May 25. July 28, on fertilized portion, 24 to 30 inches high, grain well filled and in the milk; on unfertilized, 15 inches high, grain filled a little later. August 14, grain hardening, frost did no visible harm. The crop was thrashed for seed.

Tract B.—Seeded May 25. Coming up June 4. July 29, where fertilized, 30 to 34 inches high; where unfertilized, 16 inches high; grain half filled in both plats. August 14, frost damaged the grain; later frosts spoiled the crop.

Tract D.—Seeded May 28. Coming up June 1. July 28, on fertilized ground, 33 to 36 inches high; on unfertilized, 24 inches high; both heading and grain forming. August 14, frost damaged the grain.

Sixty-Day: Sowings of this variety were made as follows:

Tract A.—Seeded May 12. Coming up May 25. July 28, on the fertilized portion, 28 to 33 inches high, grain well filled and in the milk; on unfertilized, 12 to 16 inches high, grain filled a little later. August 14, grain in the dough. Harvested August 30 for seed. The heavy frost did no visible damage.

Tract B.—Seeded May 25. Coming up June 4. July 29, on fertilized area, 30 to 33 inches high; on the unfertilized, 16 to 20 inches high; grain in both crops one-third filled. Frost of August 14 damaged the grain.

Tract C.—Seeded May 23. Coming up June 2. July 28, where fertilized, 34 to 38 inches high; where unfertilized, 20 to 30 inches high; both plats heading and grain just forming. August 22, grain in the dough and no visible damage from frost of August 14. Later frost damaged it some, and it was cut for feed.

Tract D, lower bench.—Seeded May 11, broadcast on new ground and summer fallow of the first seeding. Coming up May 24. July 28, on summer fallow, 26 to 33 inches high; on burned spots of the new ground, 34 to 38 inches high; grain in both plats nearly filled. August 21, grain about ripened, showing some damage from frost. The crop was harvested and thrashed. The new ground plat was not worth cutting.

Improved Ligowo: Sown on tract A May 12. Coming up May 25. July 28, where fertilized, 26 to 32 inches high; where unfertilized, 15 to 25 inches high; grain in both plats filled and in the milk; fertilized plat a little furthest advanced. August 14, grain in the dough; the grain did not show any damage from August frost. Harvested for seed August 30.

Duppaur: Sown on tract A, May 12; all fertilized. Coming up May 26. July 28, 30 to 36 inches high, grain two-thirds filled. August 14, grain in the milk. August frost spoiled the grain.

Burt Extra Early: The seed of this variety was sown on all four tracts.

Tract A.—Seeded May 12. Coming up May 25. July 28, on fertilized part, 30 to 33 inches high, grain well filled and in the milk; straw turning; on unfertilized, 20 to 24 inches high, grain filled a little later. August 14, grain hardening. Grain not visibly damaged by August frost. Crop thrashed for seed (Pl. V, fig. 2).

Tract B.—Seeded May 25. Coming up June 4. July 29, on fertilized portion, 24 to 28 inches high; on unfertilized, 12 to 18 inches high; grain in both plats three-fourths filled. August 14, heavy frosts damaged the grain and the crop was cut for feed.

Tract C.—Seeded May 23. Coming up June 2. July 28, on fertilized plat, 36 inches high, grain half filled; on unfertilized, 20 to 24 inches high, grain filling a little later. August 14, grain damaged by frosts. August 22, straw about ripe, cut for feed.

Tract D, lower bench.—Seeded May 10 on summer fallow of first seeding and third-year ground. Coming up May 23. July 28, on old ground, 18 to 20 inches high, grain nearly in the dough, straw about ripe enough for hay; on summer fallow, 24 to 33 inches, grain well filled and in the milk, straw turning. August 7, grain on the old ground ripe and cut for seed; summer fallow a little damaged by frosts August 14, part cut for hay and part allowed to ripen which was thrashed to test for seed. The summer fallow ground made a 50 per cent larger crop than the old ground.

Burt Extra Early was the first to ripen by several days and was thrashed before any frost. Finnish, Swedish, Select, Sixty-Day, Improved Ligowo, and Tartar King ripened about together. The early seedings of these varieties showed no injury from frost of August 14.

GRASSES (THIRD SEASON'S GROWTH).

The grasses all did poorly, the season being too dry.

Tall meadow fescue (*Festuca elatior*): June 1, poor stand and new growth backward. July 1, 20 inches high; heading. July 29, seed stalks about 36 inches high; scattering. September 1, no seed matured.

Timothy (*Phleum pratense*): May 5, new growth started. June 1, looking fair. July 1, 12 to 18 inches high; headed; suffering for moisture. July 15, blooming; growth uneven. July 29, bloom falling and seed well formed. September 1, seed ripened. Guano was scattered on a portion of the plat in the spring, but there was not sufficient rain to carry it into the soil until late in the season; this part is much greener at the close of the season.

Meadow foxtail (*Alopecurus pratensis*): June 1, stand very thin; growth well started and throwing out seed stalks. July 1, seed stalks scattering, 24 inches high. July 15, bloom falling; crop very light. July 29, seed nearly matured. August 15, seed was ripe.

Brome grass (*Bromus inermis*): May 15, up enough for good pasture. July 1, 12 to 18 inches high; some seed stalks 29 inches high and headed. July 15, stalks scattering, 24 to 30 inches high; good lower growth. July 29, stalks 30 inches tall; lower growth shorter than last year. September 1, seed did not ripen. Three acres were seeded to this variety May 12 of this year. It being very dry, the grass did not make much growth; however, the ground is quite well covered at the close of the season.

Redtop (*Agrostis vulgaris*): June 1, getting quite green; seed stalks showing. July 1, 12 to 18 inches high. July 15, good stand; heads opening. July 29, 24 inches high; seed formed. September 1, seed ripened.

Blue grass (*Poa pratensis*): May 15, showing green. June 1, seed stalks started, some heads showing. July 1, 20 to 24 inches high; very thin stand. July 28, seen nearly matured. August 14, seed ripened.

Orchard grass (*Dactylis glomerata*): June 1, getting green very slowly, partly winterkilled. July 1, little growth, very thin. July 29, good bunches thinly scattered over the ground; no seed stalks thrown out this season.

Tall meadow oat grass (*Avena elatior*): June 1, started late, a few stalks showing. July 1, 24 inches high; a few heads showing; looking poorly. July 15, 36 to 42 inches high; very thin on the ground; heads opening. July 29, seed formed. August 15, seed ripened.

Small plats of timothy, meadow fescue, orchard grass, brome grass, and hassock grass seeded in 1904 all made about the same growth as those of the 1903 seeding. Hassock grass of both seedings dead. The same sown this year did not come up. Red, white, and alsike clover of the 1903 and 1904 sowings were killed by the winter. The plats were reseeded this year, but made very little growth. Perennial rye grass was winterkilled and the plat was reseeded, but it also made very little start. *Holcus lanatus* was sown June 6, of this year. The soil kept so dry that the seed germinated very slowly and made a poor stand and little growth.

VEGETABLES.

PEAS.

Marblehead Mammoth: Planted May 12. Coming up May 23. July 15, vines thrifty, 24 inches high; supported with brush. July 23, blooming. July 29, 36 inches high; good setting of pods. August 14, just ready for first picking when heavy frost killed the whole vine.

Alaska: Seeded May 12. Coming up May 23. First picking July 20. The first setting ripened for seed. August 14, the frost killed the vines.

Prolific Early Market: Seeded May 12. Coming up May 22. July 15, full of bloom; some pods. First picking July 20. The first setting matured seed. August 14, frost killed the vines.

LETTUCE.

Early Curled Silicia, Philadelphia Butter, and Big Boston all sown in the open ground May 26. Were ready for the table July 1. The first named did the best; all made large plants.

SPINACH.

Long Standing: Coming up June 2. July 1, quite ready for the table. The plants became very large, and where not cut back the stalks were covered with seed, although it did not mature.

KALE.

Dwarf German: Only a few seeds grew. August 15, the few stalks were looking fine, 12 inches high and 18 inches across; very brittle.

RUTA-BAGA.

Purple Top Yellow Swede: Sown in boxes and open ground. Box plants set out June 8. Both seedings made excellent growth, showing large tops. Roots did not develop much till late in the summer. Those sown in the open were pulled September 2 to clear the field for pasture. The roots averaged of good size; the largest with top weighed 7 pounds. Those transplanted from boxes made a handsome crop; roots nearly all good size; largest weighed 7¼ pounds. The crop was pulled late in September. A few plants from the box seeding sent up seed stalks.

TURNIP.

White Strap-Leaf: Roots were large enough for table use July 15; tops large. This variety did well; still growing when pulled September 2 to open the pasture. The largest weighed 8 pounds. This variety suffered from a slight attack of the root maggot.

Purple Top White Globe: Large enough for use July 15. The crop was pulled September 2, for same reason as above. This variety did unusually well; roots averaged 5 to 6 pounds; largest with top weighed 11 pounds; sweet and tender.

RHUBARB.

Old plants from seed sown in 1903 made stalks of fair size for use June 15 and furnished three cuttings.

Winter Crimson Forcing: Seeds planted in the open garden June 3. July 1, up with fourth leaf. July 15, plants looking well and getting to be of good size. September 1, the stalks from these young plants would almost do for use; some seed stalks were sent up 12 inches high.

CUCUMBER.

Early Cluster: Seeded in the open May 26. July 1, plants looking fair, fourth leaf forming. July 15, plants thrifty; about vining. July 29, vines started; blooming and some cucumbers setting. August 14, some cucumbers 1 inch long when the vines were killed by frost.

BEANS.

Broad Windsor: Seed planted May 26. Coming up June 10. June 15, plants 1 inch high; healthy. July 1, average 9 inches high; looking well; branching out some. July 15, blooming. July 29, many pods showing, some filled enough for table use; still blooming. August 14, frost killed the vines. From August 1 until the vines were killed they were full of large pods well filled and excellent for green beans; only a few had been used, as we hoped that the seed would mature.

Horse Bean No. 7024: Seed planted May 26. Coming up June 9. June 15, 2 inches high. July 1, 9 to 12 inches high; not healthy looking. July 15, looking better; blooming. July 29, pods filled and about ready for use as green beans. The crop was light and all the beans had been saved, hoping to mature seed, but a heavy frost August 14 killed the vines.

CORN.

Early Crosby Sweet No. 10: Seed planted May 26, on lower bench near cottage. Coming up June 10. July 29, some stalks 16 inches high; many suckers. August 14, frost killed all the stalks. Another planting, on the upper bench, May 24. Coming up June 9. July 28, stalks 10 to 12 inches high. August 14, all killed by frost.

Pride of the North No. 8: Planted May 26, on lower bench. Coming up June 8. July 29, 15 inches high. August 14, all killed by heavy frost. Another planting, on the upper bench, was made May 24. Coming up June 7. July 28, many stalks strong and healthy; 12 inches high. August 14, all killed by frost.

Ne Plus Ultra No. 9: Planted May 25, on lower bench. Coming up June 12. July 29, 6 to 7 inches high; many suckers. August 14, killed by heavy frost. Another planting, on the upper bench, made May 24. June 15, none up. July 28, stalks 6 to 7 inches high. August 14, all killed by the frost.

POTATOES.

Extra Early Ohio: Planted May 26, on lower bench. First coming up June 9. July 1, tops getting good size and looking healthy. July 15, looking fine; making top fast; some bloom showing. July 29, tops of good size, very dark and of healthy color. August 14, vines killed by frost. September 5, 21 hills yielded 10 pounds, mostly small marketable potatoes, a few the size of goose eggs.

Garfield: Planted May 26, on lower bench. Coming up June 11. July 1, tops thrifty and getting good size. July 15, looking fine; making top fast; some blooms showing. July 29, vines strong and healthy. August 14, frost killed the vines. September 8, 40 hills yielded 22 pounds of potatoes, many of good marketable size.

Freeman: Planted May 26, on lower bench. First coming up June 1. July 1, making good tops and looking healthy. July 15, blooming some days. July 29, vines large and healthy. August 14, vines killed by frost. September 8, 57 hills yielded 36½ pounds of potatoes. About half of the crop was of fair marketable size; many the size of hen's eggs.

The three varieties were also represented on the upper bench; the land was new and the yield was somewhat lighter. The vines were killed by frost August 14, as on the lower bench. All the potatoes grown here have been of the finest quality, but the yield so far has been light.

CABBAGE.

We did not try cabbage this year, but a number of small heads were grown in private gardens. The seed was planted in open ground as soon as soil could be prepared. The largest head seen was from G. S. Clevenger's garden, and weighed 2¾ pounds.

OTHER VEGETABLES.

Radishes, carrots, onions, beets, parsnips, cress, and parsley all did fairly well in the station and in the neighboring gardens.

NURSERY.

A small collection of nursery stock was sent through the mail from Sitka Station. Stock seemed to be in fair condition when received, and was set in the ground at once. Most of the rooted trees are alive, but they made little growth. Two gooseberry, three raspberry, and nine currant plants lived, but made little growth. Early in September the rabbits invaded the garden, and before they were detected the nursery trees had been eaten to the ground. It is evident that if anything is to be done in the line of horticulture, the trees will have to be protected from rabbits.

STRAWBERRIES.

Judge Holman presented the station with 12 plants, reserving the same number for his own garden, but none of the plants in either garden started.

FLOWER GARDEN.

The flower garden was small and received little attention; yet it was admired by many.

The pansy bed of plants 1 year old has supplied the neighborhood with blossoms throughout the entire summer. Crimson Flax, Candytuft, and Nemophila began blooming about July 25, continuing through the summer. Poppies and Larkspur both did well.

FALL SEEDING.

Several varieties of winter wheat and winter rye were sown on both the upper and lower benches July 27 and August 3. The several varieties came up quickly and made excellent growth, soon covering the ground. About the middle of September observations were made on the growth and it was found that the upper bench plats had been destroyed by rabbits since my last visit a week before. There were five plats covering one-fourth acre. The lower bench plats were also attacked, but it was discovered in time to make a temporary rabbit-proof fence around some small plats before they were seriously damaged. The rabbits were very numerous this fall, and the vegetation was killed by frost unusually early, which probably accounts for their invading our fields. Winter grains were grown the two previous years and the rabbits, though plentiful, did not damage our crops.

LIVE STOCK.

The station now has a team of two fine bay horses and one milch cow and a heifer calf. The horses were wintered at the station last winter principally on native hay, with a small daily allowance of grain hay (Pl. V, figs. 3 and 4). The team kept in good flesh until put to work February 15, freighting in the station supplies. From that time the animals were reduced some in flesh, having had no grain feed through the winter before being put to work.

The cow and calf were brought to the station August 20 of this year. The cow was then giving about 20 pounds of milk daily. The trip overland from Valdez was hard on the calf and the cow gave a very poor quality of milk for some days. The milk is now of good quality. A few days after the cow arrived the milk flow increased to about 28 pounds per day; but the early frosts spoiled the feed so much that we had to begin feeding all the stock early in September, and the milk flow has dropped back to 15 or 18 pounds per day. The total yield of milk from August 21 to September 20 (thirty days) was 644 pounds.

WORK AT THE RAMPART STATION.

WEATHER CONDITIONS FOR THE YEAR.

By residents of the interior the winter of 1904–5 was considered mild. Only once did the thermometer indicate 50° below zero, the average temperature for the winter months being, on an estimate, between 30° and 35° below zero. Thin ice began running in the river October 16, but it was not until October 20 that it seemed as though winter had begun. November 9 the ice blocked in the river, and in a few days it was frozen over solid and so remained until May 16 of this year. The maximum thickness of the ice was 4 feet.

The first snow to remain on the ground fell October 2, and by the end of that month there were 6½ inches. The total snowfall for the winter was about 18 inches, and half of this did not fall until early in February. This snowfall is considerably below normal, as there is often 4 feet in this locality.

Early in April conditions seemed to point toward an early spring. The days were bright and clear and the sun warm, but toward the middle of the month it got colder again and the snow stopped melting for a while. By May 5 the snow had disappeared from the plowed ground, and by May 10 it was all gone except in sheltered spots. By May 15 part of the ground broken up in the fall was dry enough to harrow, and on May 18 the first sowing of grain was made.

Taken as a whole the summer was the most unfavorable one from an agricultural standpoint since the station was established in 1900. It was characterized by cloudy, rainy, windy weather and cool nights. The rainfall, 6.7 inches from June 10 to September 15, inclusive, was above normal, but was not excessive, had it not been accompanied by so much cloudy weather and such cool nights during July and August, the best growing months. Once during July the thermometer dropped to 32° F., and several times to 33°, the average minimum daily for the month being 42.9° and the average maximum 68.6°. During the first week of August occurred the warmest weather of the summer, the highest temperature recorded being 96°. From June 10 to September 15, inclusive, a period of ninety-eight days, there were forty-two cloudy, thirty-four partly cloudy, and twenty-two clear days. The number of cloudy days is much above normal, according to common report.

The first frost came August 19, when the temperature fell to 29°. Between that time and the end of the month there were five more, but all were so light that only the tenderer things were injured. The first killing frost did not occur till September 13, the thermometer falling to 17°. During the last week of September there were several wet snowfalls, an unusual occurrence so early in the season, but most of it melted.

Persons who have been residents of Rampart since 1897 say this has been the most unfavorable summer since their arrival.

PROGRESS OF STATION WORK.

During the winter some 175 logs were cut for use in station buildings, and 35½ cords of wood, which were exchanged for team work in doing the spring seeding, etc. Other work during the winter and spring was done as the weather would permit.

From July 19 to August 10 the superintendent, Mr. F. E. Rader, accompanied by the special agent in charge, made a tour through the lower Tanana River Valley and helped survey a reservation near Fairbanks.

No help was hired prior to July 1, but since that time one man has been employed by the day. In addition to routine work and caring for the crops, 2½ acres have been added to the cleared land, making a total of 5½ acres available for crops next year. The weather permitting, all of the cleared land will be plowed this fall and put in readiness for seeding next spring.

No station buildings were erected this year with the exception of a small temporary stable. The lumber is on hand for the erection of a frame cottage next summer, the foundation for which will be prepared this fall. The lumber was obtained from the post sawmill at Fort Gibbon, 75 miles down the river from Rampart. By permission of the War Department, and through the courtesy of the commanding officer and the quartermaster at Fort Gibbon, 10,000 feet of logs were sawed into lumber at the post sawmill at the actual cost of the labor required. The lumber was delivered by the United States transport *Jeff C. Davis*, the station furnishing the necessary fuel for the trip.

Early in September a small consignment of freight was received from Seattle consisting of harness, wagon, drag, scraper, nails, etc.

FIELD CROPS.

The 2½ acres cleared last year was nearly all seeded to different varieties of spring grain and common oats for feed. Seeding was begun May 18 and continued at intervals, as the ground became dry enough to harrow, till June 6. As compared with last year, the first seeding was nearly two weeks later, the half acre in grain having been seeded in May 5.

Being practically all virgin soil without fertilizer of any kind, the stand of grain was very irregular on much of the land. On the spots where stumps had been burned the grain made a fine growth, but elsewhere the stand was thin and the straw short and spindling.

Following are the varieties sown and the notes on their growth:

BARLEY.

Mansbury (Sitka-grown seed): Seed sown May 19. June 1, up. June 15, good stand, 3 inches high. July 15, best 24 inches high; occasional heads appearing. August 1, height 48 inches; fully headed and beginning to bloom; fine appearance. August 15, grain in medium dough. September 1, ripening. September 6, harvested; heads of good length and well filled.

Mansbury (Rampart-grown seed): Sown May 19. June 1, up; looking well. June 15, good stand; 3 inches high. July 15, height 18 inches, best 27; partially headed. August 1, best 50 inches high; all headed and in bloom; best in the field. September 1, nearly ripe. September 6, harvested; fine well-filled heads. Last year this variety was ripe and harvested August 15, but the straw was neither so tall nor the heads so large. There seem to be very little difference between the growth of the Sitka and of the Rampart seed.

Minnesota, No. 105: Sown May 18. June 1, up. June 15, fair stand; 2½ inches high. July 15, height of best, 24 inches; occasional heads showing. August 1, height 42 inches; headed and in bloom; one end of the plat very good. August 1, filling well. September 1, nearly ripe. September 6, harvested; heads of good length.

Lapland (Sitka-grown seed): Sown May 18. June 1, coming up. June 15, fair stand; 2½ inches high. July 15, average height of best, 24 inches. August 7, height 42 inches; headed and blooming. August 15, filling. September 1, grain in hard dough and nearly ripe. September 15, harvested; heads fair.

Flying Dutchman: Seeded May 20. June 1, up. June 15, fine stand; 3 inches high. July 15, heading; height 21 inches. August 1, all headed, but not filling yet. August 15, fairly well filled. September 1, grain in hard dough. September 5, harvested; straw and heads rather short.

OATS.

Burt Extra Early: Seed sown May 19. June 1, coming up. June 15, fair stand, 3 inches high. July 15, height of best, 22 inches, one-half headed. August 1, in bloom; height of best, 36 inches. August 15, filling. September 12, ripe. Several short rows of this variety was sown in ground under cultivation for several years. It did better and ripened by September 5. The straw of this variety was rather small and short and the heads were heavy.

Finnish Black: Seed sown May 19. June 1, up. June 15, rather poor stand; 3 inches high. July 15, height of best, 21 inches. August 1, heading; height, 36 inches. August 15, just beginning to fill; height, 48 inches. September 1, grain in the dough, and occasional ripe head. September 12, partially ripe. This variety ripened fine heavy grain by September 1 last year.

Swedish Select: Seed sown May 18. June 1, up. June 15, fair stand; 2½ inches high. July 15, best 18 inches high. August 1, heading; 36 inches high. August 15, just past blooming. September 1, grain in the milk. Did not ripen.

SPRING WHEAT.

Saskatchewan Fife (Canadian seed): Sown May 19. June 1, coming up. June 15, good stand; 2½ inches high. July 15, height 15 inches; best 24; looks fairly good. August 1, height 32 inches; headed; looks well. August 15, in full bloom. September 1, filling slowly. Did not ripen.

Velvet Chaff Blue Stem (Canadian seed): Seed sown May 19. June 1, up. June 15, excellent stand; 3½ inches high. July 15, height 18 inches; looks well. August 1, all headed. August 15, in full bloom; looks fine. September 1, 48 inches; grain in soft dough. Partially ripened.

RYE.

Spring rye: Sown May 19. June 1 up in fine shape. June 15 extra fine stand; 4 inches high. July 5, beginning to head. July 15, height 34 inches; fully headed. August 1, height 50 inches; in bloom; looks fine. August 15, beginning to fill. September 1, grain in medium dough. September 13, partially ripe. This variety began to head forty-seven days from time of seeding, and gave promise of maturing in good season, but it filled so slowly that it did not fully ripen.

BUCKWHEAT.

Russian: Seed sown June 2. June 15, just coming up. July 1, very good stand; average height about 1½ inches. July 15, average height 4 inches; yellowish; doing quite well. August 1, height 18 inches; in bloom; yellow color has disappeared. August 15, forming grain. One of the very few things killed by frost August 19.

WINTER GRAIN.

A small plat of each of the following varieties of winter grain was seeded August 17, 1904. It came up in good shape, but was eaten off once by the rabbits before a fence was completed. It made a fairly good growth again before the cold weather set in. During the winter the plats were covered with snow varying in depth from 8 to 24 inches. As soon as the snow left the grain it began to grow, and it was soon apparent that the varieties covered the deepest stood the winter the best. It began to head in good time but was very slow in filling and ripening.

Amber Winter Rye: Seed sown August 17, 1904. June 1, 1905, fine stand; 6 inches high. July 1, fully headed; height 42 inches. July 15, height 50 inches;

in full bloom. August 1, height 54 inches; grain in the milk; good appearance. August 15, filling slowly. September 1, ripe; grain plump. September 5, harvested.

Excelsior Winter Rye: Sown same as above. June 1, badly winterkilled; one-fourth standing; height 6 inches. June 15, average height 18 inches, best 24; heading. July 15, in full bloom; 48 inches high. August 1, grain in the milk; filling slowly. August 15, grain in the dough. September 1, about ripe. September 5, harvested.

Giant French Winter Rye: Seeded same as above. June 1, height 4 inches; partially winterkilled; two-thirds of a stand. July 1, fully headed; average height 36 inches. July 15, in full bloom; 42 inches high. August 1, just through blooming. August 15, grain in soft dough. September 1, ripening slowly. September 5, harvested.

Kharkov Winter Wheat: Seeded same as above. June 1, almost all winterkilled; height 2 inches. July 1, height 12 inches. July 10, beginning to head. July 15, two-thirds headed; height 24 inches. August 1, mostly through blooming; height 32 inches. August 15, grain in the milk. September 1, grain in soft dough. Did not fully ripen. This variety did not have a fair chance.

A plat of each of the same varieties of winter grain was seeded again this year, August 18, on ground broken up a year ago. It has made a fairly good growth.

VEGETABLES.

With the exception of the potatoes, the vegetables were planted on ground under cultivation since 1900, but which has never been fertilized. The slow growth is attributed mostly to the unfavorable season.

POTATOES.

Burbank: This was Rampart seed grown by Capt. A. H. Mayo, who raises a good crop every year.

Early Rose: Seed obtained from Mr. Peter Lundien, Eagle, Alaska, who raises a good crop of potatoes every year.

These potatoes were planted on new ground without any fertilizing. They were slow in coming up and made a poor growth. The tubers were mostly small and the yield about equal to the seed planted. A few of the Early Rose were planted on old ground. They did much better, the yield being fivefold and the tubers of good size. All were dug September 13.

PEAS.

Prolific Early Market: Seed planted May 29. June 8, coming up; June 15, 1 inch high. July 1, height 6 inches; doing well. August 1, in bloom; injured by high winds. August 15, some pods fit for use. September 1, injured some by frost, but still blooming; fair yield of peas.

BEETS.

Crimson Globe and Eclipse: Seed planted May 29. June 12, coming up. July 1, good stand; 1 inch high. July 15, growing quite well; height 3 inches. August 1, doing well. September 8, beets pulled. They were small, many not being large enough for use.

ONIONS.

Extra Early Brown Spanish: Planted May 29. June 20, coming up. They grew very slowly all summer and attained a size of from one-half to three-fourths of an inch in diameter. Will make good sets for next year.

LETTUCE.

Big Boston and Philadelphia Butter: Seed sown thickly in the open ground May 29. June 10, up; grew very slowly and was not ready for use until July 20; then furnished all we could use till covered by snow.

RADISHES.

Scarlet Turnip: Planted in the open ground May 29, and at several intervals during the summer. They grew large enough for use in four or five weeks.

White Strasburg: Seed planted May 29. June 8, up. July 15, growing very rapidly. July 20, large enough for use.

RHUBARB.

Seeded June 1. About a dozen and a half seeds germinated and made a very satisfactory growth. They will be taken up and reset in the spring.

SPINACH.

Long Standing: Seeded June 1. By June 12 it was up, and ready for table use by July 15. Cut five or six times during the summer.

SALSIFY.

Seed planted June 1. June 20, up. July 1, quite good stand; 2 inches high. Grew very slowly, and by September 8 the roots were not yet large enough for use.

PARSNIPS.

Early Round: Planted June 1. June 23, up. Grew too slowly; did not get large enough for use.

CARROTS.

Scarlet Horn: Seed planted June 1. June 20, up. July 1, growing very slowly. Did not get large enough for use. Usually a sure crop.

TURNIP.

Large White Norfolk: Seed sown June 1. June 10, up. July 1, fair stand; 1½ inches high; leaves full of small holes caused by an insect. July 15, growing very rapidly; insects still working some. August 15, many roots large enough for use. Pulled September 8; did exceedingly well; very tender and sweet; a sure crop here.

RUTA-BAGA.

Champion: Seed sown June 1. June 10, up. July 1, fine stand; 1½ inches high. July 15, growing very rapidly; not attacked by insects. September 1, some roots of good size, but the majority rather small. Pulled September 8. Should have been planted earlier; usually a sure crop.

BRUSSELS SPROUTS.

Dwarf Improved: Seed sown in window boxes about May 5. Transplanted June 12. Grew very slowly; sprouts just beginning to form at the end of the growing season.

CABBAGE.

Early York, Early Jersey Wakefield, Surehead, and Early Winningstadt: Seed sown in window boxes about May 5. Transplanted June 12. Slow in starting and slow in growth; only Early Jersey Wakefield made small heads.

CAULIFLOWER.

Extra Early Paris: Seed sown in window boxes about May 5. Transplanted June 12. Grew very slowly. Just beginning to head at close of the season.

Early Snowball: Seed sown in hotbed May 10. Transplanted June 19. Grew quite well and produced several nice heads.

FLOWERS.

The flower garden was quite a success in spite of the unfavorable season. The following varieties were started in the window boxes during May and transplanted during June: Pansies, poppies, cornflower, and nasturtiums. The following were planted in the open ground: Sweet peas, gillia, and candytuft. They began blooming about July 20, and many of them continued to bloom profusely till the frost of September 13.

DISTRIBUTION OF SEED.

In addition to the garden seed sent directly from the Department to residents of the interior of Alaska, there is quite a demand among the miners and prospectors who have no fixed abode for such seed as radish, lettuce, turnip, and ruta-baga—things that grow quickly and require no particular care. The stores do not have seeds for sale, and these persons have to depend on the station for their supply. The several hundred packages distributed last winter and spring through the Rampart Station have been the source of considerable satisfaction to the miners and others.

WORK AT THE KENAI STATION.

WEATHER CONDITIONS.

The snow was gone by April 9, which was unusually early. The season advanced slowly, with frequent southwest winds, which held vegetation in check. After July 15 the weather was more favorable than the normal for that season of the year, and heavy showers alternated with sunshine. A heavy frost August 26 and 27 injured grain to a considerable extent.

May had twelve clear and six cloudy days; precipitation, 0.84 inch. June, sixteen clear, seven cloudy, with 0.84 inch precipitation. July, thirteen clear, twelve cloudy, with 1.06 inch precipitation. August, twelve clear, twelve cloudy days; precipitation, 6.26 inches; this is the greatest precipitation for any one month on record at this station. The number of clear days was normal, however, the increased precipitation being due to heavier showers than usual.

WORK ACCOMPLISHED.

Twenty-three acres of land are now under cultivation. The greater part of this was seeded to oats and barley to provide forage for the live stock, which now consist of 11 cows. (Pl. VI, fig. 1.) The remainder of the land was used for the cultivation of legumes, grasses, vegetables, bush fruits, and

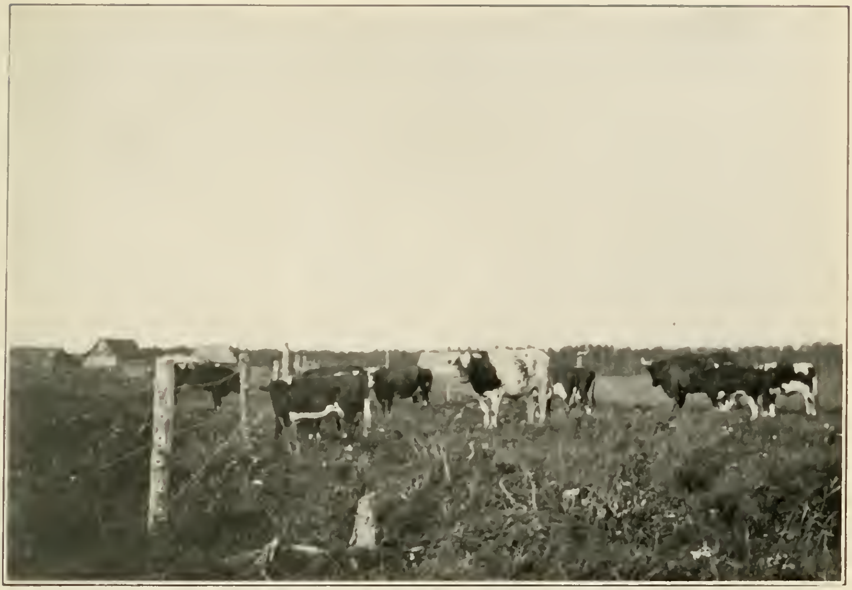


FIG. 1.—STATION HERD, KENAI STATION.

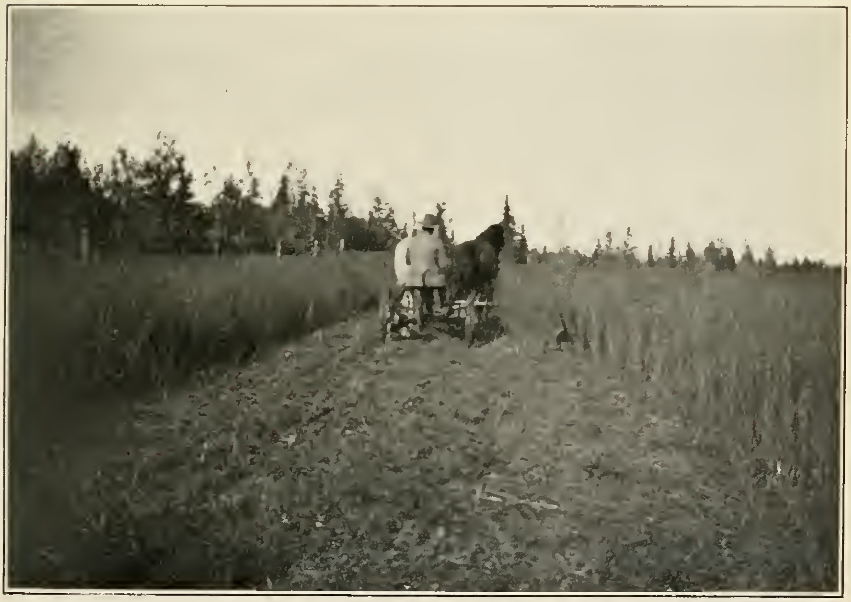


FIG. 2.—CUTTING GRAIN AT KENAI STATION.

fruit trees. Milk and butter have been sold and a record kept of the sales. Records have also been kept of the milk yields, weather, and soil temperatures. No additional land clearing was attempted this season. All the time which could be spared from growing crops was used in improving the house and grounds. A road was made to the beach, and over this gravel was hauled to make walks from the house to the outbuildings. Old bricks were used as border for the walks. A number of spruce and birch trees were transplanted in the yard. The house has been recalked, lined with building paper, and all of the downstairs rooms have been repapered, which will make the house more comfortable than heretofore.

ADDITIONAL EQUIPMENT.

A mowing machine was added to the equipment August 2, and this will greatly lessen the time necessary to gather the hay. (Pl. VI, fig. 2.)

Six hens were purchased of a native of this place, and during August they laid 8 dozen eggs. These hens were fed on table scraps.

GRAIN.

FIELD OATS.

Field A.—Seeded May 22. June 15, 3 inches high; fair stand. August 1, 8 to 30 inches high; 50 per cent headed. August 15, 24 to 36 inches high. Grain was in the milk when injured by frost August 26 and 27.

Field B (first planting).—Seeded May 27. June 15, 2 inches high; fair stand. July 1, 4 inches high; good stand. August 1, 24 inches high; 25 per cent headed. August 15, 26 inches high; fully headed. September 1, 40 to 48 inches high; in the milk when injured by the frost.

Field B (second planting).—Seeded June 10. July 15, 4 inches high; fair stand. August 1, 12 inches high; no heads. August 15, 24 inches high; 50 per cent headed. September 1, 24 to 40 inches high.

Field C.—Seeded May 30 and 31. June 15, 1 inch high; uneven stand. July 1, average 4 inches high; good stand. August 1, 30 inches high; some heads showing. August 15, 36 to 40 inches high; 75 per cent headed. September 1, 48 to 60 inches high. Some of the grain was injured by frost.

BARLEY.

Hanna Two-Row: Seed sown May 26. June 15, 3 inches high; good stand. July 1, average 4 inches high. August 1, 36 inches high; 75 per cent headed. August 15, 36 inches high; fully headed. September 1, 40 inches high; some in milk and some in dough when injured by frost.

BUCKWHEAT.

Seed sown May 26. June 15, just coming up; good stand. July 1, 2 inches high; not thrifty. July 15, 2 to 10 inches high; some in bloom. August 1, 20 inches high; in full bloom; looking well. August 15, 30 inches high; seed formed. There was a small percentage of ripe seed when killed by frost August 26.

LEGUMES.

BEANS.

Horse Bean No. 2453: Seed planted May 4. June 15, 1 inch high; excellent stand. July 1, 4 inches high. July 15, 10 inches high. August 1, vines 24 inches long. August 15, vines 30 inches long; 50 per cent in bloom. September 1, vines 36 inches long; in full bloom; no seed formed.

Horse Bean No. 2455: Seeded May 4. June 15, 1 inch high; good stand. July 1, 4 inches high. July 15, 6 inches high. August 1, 18 inches high; a few blossoming. August 15, in full bloom; vines 24 inches long. September 1, vines 30 inches long; no seeds formed.

Horse Bean No. 7024: Seed planted May 26. June 15, only a few shoots showing. July 1, 2 to 6 inches high; poor stand. July 15, 12 inches high. August 1, 20 inches high; in bloom; beaten down by rain. August 15, pods formed; beans one-half the size of peas. Killed by frost August 26.

GRASSES.

Meadow foxtail (*Alopecurus pratensis*): Seed sown 1902. June 15, 24 inches high; fully headed. July 1, 30 inches high. Cut for hay July 1.

Timothy (*Phleum pratense*) of 1902: June 15, 6 inches high. July 1, poor, uneven growth; average 10 inches high. Cut for hay July 1.

Awnless brome grass (*Bromus inermis*), sowing of 1902: June 15, 12 inches high; July 1, 20 inches high. Cut for hay July 1.

Awnless brome grass (*Bromus inermis*), 1903: June 15, 12 to 16 inches high; good sod. July 1, 20 to 30 inches high; thrifty. July 15, 20 to 36 inches high. Cut for hay July 23.

Meadow foxtail (*Alopecurus pratensis*), 1903: June 15, 24 inches high; fully headed. July 1, 30 inches high. July 15, 20 to 36 inches high. Cut for hay July 22.

Timothy (*Phleum pratense*), 1903: June 15, 6 inches high. July 1, 12 to 18 inches high; headed. July 15, 18 to 24 inches high. Cut for hay July 22.

Tall fescue (*Festuca elatior*), 1903: June 15, 5 inches high. July 1, 12 to 18 inches high. July 15, 24 inches high; headed. Cut for hay July 22.

Redtop (*Agrostis vulgaris*), 1903: June 15, 6 inches high. July 1, 10 inches high. July 15, 18 to 24 inches high; heading. Cut for hay July 22.

Meadow fescue (*Festuca pratensis*), 1904: June 15, 6 inches high; good stand. July 1, 12 inches high; heading. July 15, 18 inches high. Cut for hay July 22.

Hassock grass (*Aira cæspitosa*), 1904: June 15, 4 inches high; poor stand. July 1, 5 inches high; heading. July 15, 18 inches high. Cut for hay July 22.

Blue grass (*Poa pratensis*), 1904: June 15, 3 inches high; poor stand. July 1, 12 to 18 inches high; heading. July 15, 18 inches high. Cut for hay July 22.

Perennial rye grass (*Lolium perenne*), 1904: Winterkilled.

Awnless brome grass (*Bromus inermis*), 1904: June 15, 8 inches high; thrifty. July 1, 18 inches high; excellent stand. July 15, 18 to 24 inches high. Cut for hay July 22.

Tall oat grass (*Avena elatior*), 1904: June 15, scant growth; 3 to 6 inches high. July 1, 12 inches high. July 15, 24 inches high; heading. Cut for hay July 22.

Tall fescue (*Festuca elatior*), 1904: June 15, 4 inches high; greater part winterkilled. July 1, 12 inches high. July 15, 30 inches high. Cut for hay July 22.

Orchard grass (*Dactylis glomerata*), 1904: June 15, 3 to 6 inches high. July 1, 4 to 12 inches high; very uneven. July 15, 12 inches high.

Tall fescue (*Festuca elatior*), 1905: Seed sown May 25. June 15, just coming up. July 1, 1 inch high; good stand. July 15, 2 inches high. August 1, 6 inches high. August 15, 12 inches high; a few heads showing. September 1, 18 inches high.

Timothy (*Phleum pratense*), 1905: Seed sown May 25. June 15, just coming up. July 1, well up; heavy stand. July 15, 3 inches high. August 1, 9 to 12 inches high. August 15, 12 to 18 inches high; a few heads. September 1, average 18 inches high.

Orchard grass (*Dactylis glomerata*), 1905: Seed sown May 26. July 1, just up; stand not good. July 15, 1 inch high. August 1, 5 inches high; heavy stand. August 15, 6 inches high. September 1, 12 inches high.

Italian rye grass (*Lolium italicum*), 1905: Seeded May 26. July 1, 1 inch high; good stand. July 15, 2 inches high. August 1, 4 inches high. August 15, 6 inches high. September 1, 10 inches high.

Mixed grasses: A mixture of all the grasses planted this season was sown June 13. July 1, just coming up. July 15, 2 inches high; good stand. August 1, 4 inches high. August 15, 6 inches high. September 1, 10 inches high.

Silver tussock grass (*Poa cæspitosa*): Seed sown in sandy bed; failed to germinate.

Native grasses: Of the native grasses sown, wild rye, wild barley, and one species popularly, but incorrectly, known as redtop, failed to grow. On August 15, the following notes were taken on native grasses: June grass, 12 inches high; bunch grass, 12 inches high; wheat grass, 3 inches high, poor looking; *Calamagrostis langsdorfii*, popularly known in this region as redtop, 5 to 12 inches high. The seeds of all these grasses were very slow in germinating, much more so than imported seed.

VEGETABLES.

The season was very favorable to the growth of vegetables until the frost of July 26. This year as well as last a large percentage of the cabbages and some of the radishes were killed by maggots. Wood ashes, which had been recommended, were applied but failed to check the ravages of the insect. This is the only native insect pest. The following is a detailed account of the growth of the vegetables:

KALE.

Improved Siberian: Sown in hotbed May 1. Transplanted to open ground June 7. A few of the plants died after being planted, but those that survived made a splendid growth and at present some of the plants measure 36 inches from tip to tip of the leaves.

LETTUCE.

Big Boston: Planted in hotbed May 1. Was not transplanted, and, since June 1, has furnished all we could possibly use on our table.

California Cream Butter: Planted in open ground June 8. Growth retarded during first month by dry weather, but was large enough for table use July 15.

Morse: Planted in open ground June 12. Large enough for table use July 20. All varieties of lettuce seem to do equally well.

CABBAGE.

Early Jersey Wakefield: Sown in hotbed May 1. A large percentage of the seed failed to germinate. Transplanted to open ground June 7. Grew splendidly until attacked by maggots, which to date have destroyed about 75 per cent of the plants.

RADISHES.

Early Scarlet Turnip: Sown in hotbed May 1. Edible June 1.

French Breakfast: The same as above.

Improved Chartier: Planted in open ground June 12. Ready for table use July 15. This is a long-rooted variety; tender, and of excellent flavor.

Long Scarlet Short-Top: Planted in open ground June 12. Ready for table use July 12.

White Icicle: Planted in open ground June 6. Ready for use July 20. This variety is pure white in color, long-rooted, excellent quality.

ONIONS.

Yellow Globe Danvers: Sown in hotbed May 1, and not transplanted. They have attained a diameter of about 1 inch.

CELERY.

Improved White Plume: Planted in the hotbed June 11. As the other plants were transplanted to open ground the celery was transplanted to their places in the hotbed. Boards were placed on either side of each row and the space around the plants was filled with earth. The plants are now 16 inches in height, have blanched nicely, and are crisp and delicious.

PARSLEY.

Planted in the hotbed May 11. Made a vigorous growth and is now 10 inches high.

PEAS.

Marblehead Mammoth: Sown June 24. A late variety making a rank, rapid growth. Large enough for table use at the end of August.

TURNIP.

Purpletop Strap-Leaf: Sown June 23. None have become extraordinary in size, but are very uniform and of excellent quality. The maggot that attacked the cabbage also attacked the turnips, but as the latter became larger the maggots disappeared.

RUTA-BAGA.

Thorburn Improved: Planted in open ground June 23. Were not attacked by maggots as turnips were. Have attained an average diameter of about 4 inches.

RHUBARB.

Became large enough for use during the first week in June and has not deteriorated in quality up to September 1. Close cutting keeps it from seeding or getting woody.

CARROT.

Scarlet Horn: Planted in open ground June 8. September 1, about 1½ inches in diameter.

BEETS.

Crimson Globe: Planted June 8. September 1, about 2 inches in diameter.

PARSNIPS.

Long Round: About 1 inch in diameter.

POTATOES.

In the spring no seed potatoes were on hand, so it was found necessary to plant from a supply brought from Seattle for table use. They proved to be a late variety, though they were of edible size by August 14. The plants were nipped by frost August 26 and 27, but continued to grow. The tubers are small in size, but a good quantity is found in each hill.

FLOWERS.

Poppies, sweet alyssum, sweet william, nasturtiums, nemophila, and sweet peas were planted June 25. The plants all grew well, and throughout the month of August furnished a profusion of bloom. Pansies sown in a box were in bloom September 1.

FRUITS.

Ten trees of each of the following varieties of apple (grafts) were planted, and the following number of each variety made more or less growth: Florence, 5; Whitney No. 2, 3; Iowa Beauty, 4; Okabena, 8; Tetabaski, 6; Charlinoff, 6; Day, 7; Whitney, 7; Early Strawberry, 8; Dutchess, 8; Yellow Transparent, 8; Brovina, 2; Sweet Russet, 6; Duchess, 7; Wealthy, 8; Illinois Siberian crab, 9.

Twelve red raspberry plants were set out, and 11 made a good growth. Five sweetbrier plants were set out, and all grew. Seven gooseberry plants were put out, but only one made any growth. Forty-three red currants were set out, and 28 have made a very good growth.

A number of native raspberry plants were set out in June, and without exception grew. Native red and black currants show a growth of 50 per cent of the plants set out. Seeds of the native strawberry and red and black currants have been gathered. Part of the seed will be sown here, and the remainder will be sent to the Sitka Station.

LIVE STOCK.

Nine head of cattle were wintered besides the three calves that were dropped during the winter months. Nothing but native feed was fed, and all the cattle were in excellent condition in the spring. The work oxen remained in good condition throughout the spring work. The increased number of animals will necessitate the sale of two steers in order to obtain sufficient stable room. These yearlings are in prime condition, and will weigh between 500 and 600 pounds each. On August 2 a 3-year-old cow and a calf were sold to Mr. O. H. Sleeper, of Sunrise, for $60. In view of the fact that the present cost of bringing cattle into Alaska is so great as to be almost prohibitive to individuals, it is believed that the development of animal industry in the country can be greatly facilitated by the station disposing of its surplus increase of stock to prospective stock raisers in the Territory at the cost of production.

A record of the milk yield has been kept as heretofore.

Milk yield of three cows.

Month.	First cow.		Second cow.		Third cow.	
	Monthly yield.	Average daily.	Monthly yield.	Average daily.	Monthly yield.	Average daily.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
November	587	24.05				
December	705	24.07				
January	669	21.57				
February	406	14.5				
March	356	11.5	619	19.96	204	22.63
April	298	9.93	577	19.26	575	19.16
May	362	10.7	599	19.32	584	18.83
June	392	13.06	701	23.36	718	23.93
July	369	10.9	646	20.83	685	22.1
August	295	9.77	586	18.77	602	19.41
Total yield	4,439		3,728		3,368	
Daily average		14.6		20.3		19.41

The feed used for dairy cows has been native pasture in the summer and native hay in the winter. If the winter feed were supplemented with silage, the yield would undoubtedly be greatly increased. In the case of cow No. 1 we have the opportunity to note the effect of winter feed. The calf was dropped in early November, and for the first three months after calving the average daily yield amounted to 22.78 pounds. The marked decrease in yield during the month of February was probably due to a change of milkers which took place at that time. The improvement owing to modern methods of milking is shown in the yield of cows Nos. 2 and 3. As explained in my last report, these cows were formerly owned by the Russian priest at this place. The Russian method of milking consists in allowing the calf to begin and finish the operation, a procedure neither economical at the time nor conducive to a heavy milk yield in the long run. In the case of the two cows the increase in the average daily yield of this year over that of last year is very marked. It is believed that the average can be raised still higher by next year.

No addition to dairy equipment has been made to date, all appliances used being homemade. No accurate work can be done until the station is equipped with up-to-date dairy utensils.

The silo has not been given the attention it should receive at this station. In the fall of 1902 a so-called silo was built of logs and filled with peas. As was to be expected, most of the peas spoiled. The first essential of a silo is that it should be air-tight, and this is hardly possible with rough-hewn logs. A silo should be built and the practicability of feeding silage in this latitude be tested. Hay is not easily cured in the fall on account of frequent showers. This fact at once suggests the silo, and the immense amount of forage that can be raised per acre here would seem to make the building of one imperative.

REPORTS FROM SEED DISTRIBUTION.

The following reports from the seed distribution tell of results obtained under ordinary conditions in all parts of the Territory, and contain valuable information which will be especially serviceable to new settlers. As noted elsewhere, the season of 1905 was very favorable in the coast region, and the gardens here gave general satisfaction (Pl. VII, fig. 2). In parts of the interior, on the contrary, the season was very unfavorable. At Rampart and for 100 miles south of the sixty-fifth parallel, and generally along the Yukon, the spring

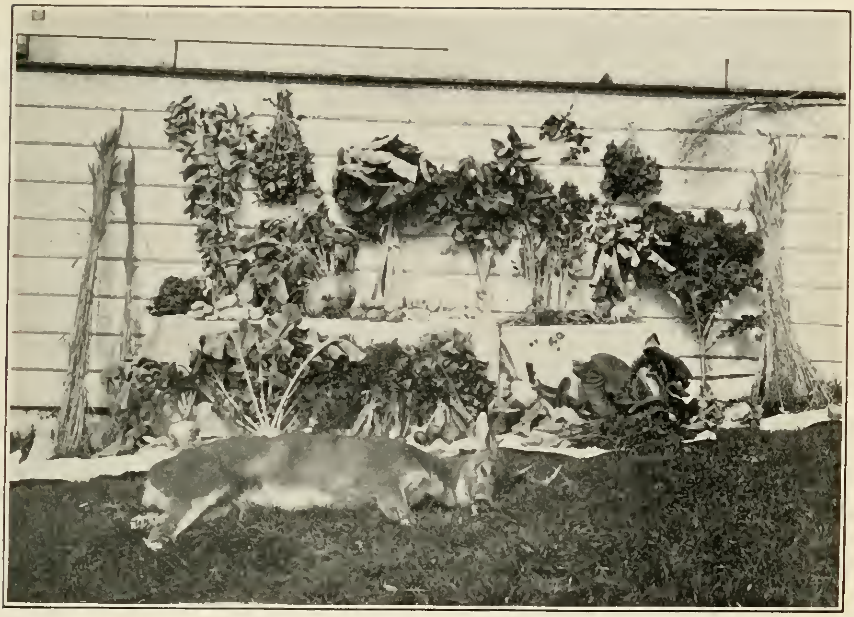


FIG. 1.—VEGETABLES AND MEAT AT SITKA.

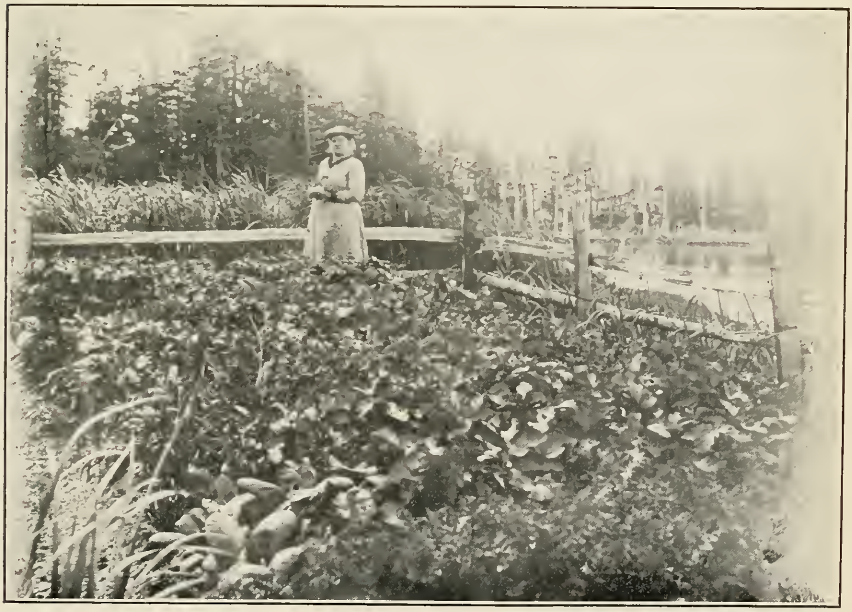


FIG. 2.—VEGETABLE GARDEN ON LA TOUCHE ISLAND—A TYPICAL PROSPECTOR'S GARDEN.

was late, wet, and cold; in the Copper River Valley, on the other hand, the spring and early summer were too dry.

James Wallace, Metlakahtla, Alaska.—June was warmer and drier than I have ever seen it in this locality; hence it was very favorable for garden purposes. Strawberries ripened six weeks earlier than last year, and everything else from two to four weeks earlier. The soil here is decayed moss and does very well if sufficient fertilizer is applied. This season I used barnyard manure, fish offal, and seaweed, and found that fish produces the best results. On two-fifths of an acre I raised 110 bushels of potatoes of excellent quality, the best crop resulting from fish fertilizer. Ruta-bagas and yellow field turnips did well; some of the former weighed 5 pounds, and one of the latter weighed 9¾ pounds. Early cabbages do well, but the season is too short for maturing late varieties. This season they have been ruined by worms boring the heads. The trees and bushes which you sent me have all taken root and are doing well, but I hardly think the climate is favorable for fruit trees. There are several cherry trees in the village. Some seasons they bear a few cherries and some seasons none.

Cattle seem to thrive on the native grasses. We got a cow and a calf from Seattle in May, 1904. The cow was very thin when she arrived, but at once began to fatten, and has been in good condition ever since. They wintered on 1½ tons of hay and a little shorts, and were out every day last winter.

Dates of planting and first use, season of 1905.

	Sown or planted.	Ready for use.		Sown or planted.	Ready for use.
Cabbage, early, sown in hothouse.	Mar. 1		Lettuce	May 5	July 4
			Turnips, Early White	May 10	July 27
Cabbage, early, transplanted.	May 5	July 30	Carrots	do	July 21
			Beets	do	July 24
Peas, Telephone	May 13	July 22	Gooseberries		June 11
Peas, Prolific Market	Apr. 12	Aug. 1	Strawberries		June 13
Onion sets	Mar. 13	Apr. 1	Raspberries		July 15
Rhubarb		Apr. 7	Currants		Aug. 1
Potatoes, Burbank	Apr. 12	July 24	Celery	June 19	Aug. 25
Cauliflower	May 5	July 22	Radishes	May 10	June 12

J. Pittenger, Ketchikan, Alaska.—I received the fruit trees you sent last spring about May 1, and planted them at once. They made growths as follows: One red Astrachan, 2 feet; 1 Sylvan sweet, 2 feet; 2 Duchess, 1 foot each; 4 seedlings, 1 foot each; 2 Barovinka, both died; 2 Strawberry, both died. The raspberry, currants, and gooseberries all grew and are doing well. I am also growing strawberries and pieplant, and both are doing well. The strawberry plants came from Metlakahtla, and the pieplant is from roots sent up from Seattle. I tried raising pieplant from seed, but it was not satisfactory, as the seed does not come true to kind. I grew a great many plants, but none of them were of large variety, so I think it is best to send and get roots that are known to be of a large kind.

In the line of vegetables I have raised this year cabbages, radishes, lettuce, carrots, and turnips; they all did well. I also sowed onion seed, which made nice green onions, but none of them were large. I also raised some very nice ruta-bagas. I planted a patch of Late Rose potatoes about May 27, and in two weeks they were nicely up and in six weeks I had a photograph taken of them, which I inclose, showing that they grew very rapidly. Till early in September they did exceedingly well, the potatoes being of good size when the vines were killed by what one of my neighbors says was potato blight. The potatoes are now decaying very badly.

Nathan B. Whitfield, Ketchikan, Alaska.—I received several kinds of seeds from you last year for experimental growth, but failed to write my report of the results in time. This year I planted as nearly the same kinds as I could obtain from the stores here. They were planted during the first week in May in two different gardens. Garden No. 1, 20 by 40 feet; fertilized the year before with manure from the cow stable; no other stimulant. Garden No. 2, 20 by 20 feet, was of virgin soil not manured.

In garden No. 1, I planted beets, cabbages, collards, kale, lettuce, dwarf peas, radishes, spinach, parsley, and White and Red Strap-Leaf turnips. They all did well. The beets grew 4 inches in diameter. The cabbage—Early Wakefield—grew to be 8 inches in diameter with firm heads; the collard—large-leaved—became 18 inches tall; the kale was not so large; the lettuce was 12 inches across from tip to tip; the dwarf peas, 2 feet high, were loaded with pods; the radishes were from 1 to 2 inches in diameter; the spinach, 10 inches across from tip to tip; the parsley was 6 inches in diameter; and the turnips, from 4 to 6 inches in diameter, solid, and with rich green tops.

In garden No. 2 I planted lettuce, peas, potatoes, strawberries, sunflowers, and the trees you sent me. Five of the trees died, being in bad condition when received. Considering the little attention paid them owing to my necessary absence, the vegetables did well, making a growth beyond my expectation and equal to those in garden No. 1. The peas grew 5 inches high and were loaded with pods; the potatoes were from 1 to 3 inches in diameter; the strawberries produced a heavy green foliage and fruit; the sunflowers became 6 feet high, are now in bloom, and will probably mature seeds before severe frost; lettuce, radishes, and peas were planted, but never matured.

The trees were received May 2, and planted May 3. Some of them were in bad condition when received. Seven of them are living and range from 12 inches to 2½ feet high. The Red Astrachan apple, apparently dead when received, was not planted. Two Borovinka, a Sylvan Sweet, and 2 Early Strawberry apples are living and have a rich green foliage. The seedlings and young grafts died. Four currant bushes, 2 feet high, and 8 red raspberry bushes 2½ feet high, are growing nicely.

The mint I planted near a stream, and it is now a bunch 18 inches across and 2 feet high.

The experiment thus far I consider a success, and with proper attention this part of Alaska can produce as fine vegetables as any other part of the world in the same latitude.

Fred Patching, Fortmann Salmon Hatchery, Loring, Alaska.—Just a few lines to let you know how the garden grew at this place this season.

The apples and raspberries you sent me last spring grew as follows: One Red Astrachan apple grew 5 inches, and one (Sylvan Sweet) grew 6 inches; four raspberries grew shoots 3½ to 5 inches long; currants grew several sprouts about 2 feet long; three seedling apples grew 18 to 21 inches long; sand cherry made a growth of from 18 to 30 inches, and fruit formed, but did not mature; the root of mint made big growth.

Cabbage, Windsor beans, lettuce, radish, ruta-baga, rhubarb, horse-radish, celery, and onions from seed all did fine, in fact, could hardly be beaten.

All of the foregoing were raised on land that has been in cultivation two or three years, and was well fertilized with fish and stable manure. On a piece of ground that measured one-third acre we raised 78 sacks of potatoes, which seems to me to be a pretty good yield. This potato land was cleared in the spring of 1904, and some vegetables were raised on it. In the spring of 1905 it was planted to Burbank potatoes, with the above result. The soil was not fertilized, but it has the appearance of having been cultivated years ago.

Dorman Newman and I. Wheeler, Game Cove, Admiralty Island, Alaska.—We sowed in hotbed on April 1 cabbage of both early and late varieties. They were slow coming up, and were not fit to set out till about May 25. On that day there were set out about 300 plants, which were watered, as we had no rain whatever here in late May or June. They grew well, and out of the lot there were not more than 10 or 12 that did not head well. The Early Jersey Wakefield gave the best results, giving a nice hard head weighing from 4 pounds up. The Flat Dutch gave larger heads, but not as solid. The beans did not come up at all, just three or four stalks showing.

Onions came very slowly, but were good for green onions when they did come. We have saved some, and intend trying them as sets next year. Both kinds of beets did well, giving some nice roots 3 to 4 inches in diameter, but rodents of some kind spoiled quite a lot of them. Carrots did well and were of quite good size. Radishes did remarkably well, and from a small patch there were more than we could use. Lettuce also did well. Turnips of any kind do well here. We had four different kinds—ruta-bagas, Purple Top Strap-Leaf, Golden Yellow, and another kind. Turnips and cabbage seem to do well in this new ground. Potatoes grow well, but are not marketable. We got better results from the seed grown here last season than from fresh seed potatoes bought in Juneau, and we are going to try the same seed again next year and use seaweed as fertilizer. So far we have used no fertilizer of any kind, but will do so next year.

We received the reports you sent, and thank you very much for them, as information of any kind on gardening is acceptable.

Edward J. Lawrence, Tree Point Light Station, Alaska.—The seeds you sent me last spring were received in due time, and I gave most of them a good trial.

I am surprised at the good results obtained at gardening for this part of the country, especially with second-year ground which had been fertilized with fish, ashes, and henhouse manure.

Radishes, lettuce, and turnips grew quickly and were of good quality.

Onions (Extra Early Brown Spanish) planted May 1 were large enough for table use July 4, and by September 19 they were 2 inches in diameter.

Cauliflower (Extra Early Paris) did exceedingly well, and was, in fact, the best I ever ate.

Peas (Prolific Early Market) were planted May 10 and did well both in quantity and quality. The first mess was picked August 6. The vines grew too rank, some of them reaching over 6 feet in height.

Beets and carrots did well; beets reached 4 inches in diameter.

All the flower seed grew and bloomed well; sweet peas and candytuft were especially fine.

C. E. Peterson, keeper Sentinel Light-House Station, Alaska.—I herewith submit a report of my attempt at garden work with the different kinds of seeds which you sent me last fall, also of the several apple seedlings and berry bushes.

I sowed peas as early as April 25, as the weather was extremely fine and warm, but they did not show up till May 11. We picked the first peas for table use August 10; the vines were then standing 4 feet high. Out of one package of seed two families were supplied with about five meals from the crop.

I sowed ruta-bagas and turnips, white and purple-top. The white turnips did the best, and were as large as saucers. Some of the ruta-bagas weighed 4 pounds, were 13 inches long and 2½ inches through, and very sweet. Parsnips did not appear till late in September and were as small as one's little finger. Carrots (Scarlet Horn) did not show up much till September 1, but at the time of this writing the average weight is about one-half pound. Radishes and lettuce grow wonderfully here considering that the ground is poor; in fact, all my vegetables did well considering the fact that they were put into ground that never had a blade of grass in it till I started the garden last spring. There was no fertilizer used except one small box of hen manure which I had saved up last winter.

The apple seedlings grew from a 5-inch stem to from 10 to 20 inches in height. The Red Astrachan made the largest growth; after it the Sylvan Sweet and four seedlings grew from 10 to 15 inches high. The two Duchess had only a few leaves. The two Borovinka did not do well, probably owing to the fact that there was not enough soil, as the soil on this island is in patches.

Flowers did remarkably well, sweet peas and nasturtiums especially. The berry plants you sent me are doing well, especially the currants, and the mint is 20 inches high.

I believe we could raise, with good fertilizer, almost anything on this rocky island. This being my first attempt, I shall no doubt do better next year. My assistant brought a few half-grown vegetables with him from Tree Point Light Station and planted them in the patch from which I had taken my turnips, and now he has cauliflower, ruta-bagas, beets, and kale. The beets from the seed you sent me are as large as my two fists and are still growing. Nothing but rotten stumps for soil, and a little rock weed covered the rocks. Whoever saw my garden this summer said I did well for a beginner with such soil. This winter we will make fertilizer with fish and rock weed or sea grass. Our potatoes were not plentiful, but some were quite large, and in taste the best I ever ate.

Gust Grundler, Douglas City, Alaska.—The following is a report of my experiments for the season:

Lettuce: Salamander; seed sown in hotbed April 1; transplanted May 15; grew very well, making large heads.

Kale: Dwarf Green Curled Scotch; seed sown in hotbed April 1; transplanted May 15; started slowly; maggots attacked the roots in July; I sprinkled sulphur around the roots, which relieved the plants of maggots, and they grew well after that; leaves about 16 inches long.

Cauliflower: Extra Early Snowball; seed sown April 1, in hotbed; transplanted May 15; started slowly; attacked by maggots the same as kale; some plants died, all the small roots being eaten off; heads 8 inches across the top.

Cabbage: Early Jersey Wakefield; seed sown April 1, in hotbed; transplanted May 15; had the same trouble with the maggots; heads 3 to 8 pounds.

Ruta-baga: Laing Improved; seeded April 1, in hotbed; transplanted June 1; roots attacked by maggots when about 1½ inches thick, eating all round the roots. After being relieved with sulphur the injured plants began to grow again, but the roots are small.

Beets: Detroit Dark Red; seed sown in hotbed April 1; germinated very slowly; transplanted June 15; after starting to grow, all the plants sent up seed stalks and did not form roots.

Radish: Glass; seed sown April 15; did not do well. The same variety sown June 10 started to grow, but maggots got the best of them, and only left the shells for me.

Turnips: White Dutch; seed sown June 10; came up fine, but are all wormy.

Onions: Extra Early Brown Spanish; seed sown June 10; roots became from one-fourth to three-fourths inches thick.

Carrots: Scarlet Horn; seed sown June 10; grew fine; good crop; no maggots on them.

Peas: Marblehead Mammoth; seed planted May 27; first picking September 10; a good bearer.

Beans: Early Red Valentine; seed planted June 1. I raised eight plants from one package of seed; the rest rotted in the ground. The plants died when 4 inches high. Everybody here who experimented with beans had the same result.

Parsley: Plain, or Single; seed sown April 1; grew fine; I have cut it three times, to dry for winter use.

Spinach: Curled Savoy; about one-fourth of the seed came up and went to seed stalks. I have had the same experience for three years.

Rhubarb: Rhubarb did fine this year; cut the last time October 1.

I have used some horse manure as fertilizer in my garden, and I blame that for producing all the maggots there. Sulphur seems to be a good remedy for them; I think it is unwise to use any horse manure as fertilizer in this section of the country. I shall put some lime in the garden; it may kill the eggs of the insects, if any are left; I shall also use some different fertilizer next year, but no fish fertilizer. A gentleman here bought some fish fertilizer in Juneau and put it in the garden just before planting; soon afterwards his garden was alive with maggots, which destroyed many plants.

The following is my experience with the apple trees you sent me: Every one of the seedlings grew about 4 inches; Early Harvest, 8 inches; Okabena, 6 inches; Borovinka grew below the grafts, new shoots about 6 inches high; the Early Strawberry died.

I gave three seedlings—one Early Strawberry, one Early Harvest, and one Okabena—to Mr. McDonald here; about two of the grafts died. Following your advice I sent to a nursery for two plum trees and four cherry trees. I selected 4-year-old trees; it is a little expensive, as the express charges on them cost me $3.40, but I shall have an early result. The plum trees have done well making a new growth of about 10 inches. The cherry trees look healthy, but did not grow any.

The berry bushes you sent me took well to the ground. New canes on the raspberries grew 2 feet; currants the same, but they did not bear any fruit. I had ten currant, ten gooseberry, and twelve strawberry plants sent from Seattle. Five of the gooseberry and four of the currants died, the rest grew very little; the strawberries grew fine and bore a few berries; I raised about forty healthy plants from them.

I had eight rose bushes and some Japanese chrysanthemums from Seattle. I have two climbing roses; they started slowly, but grew fine after they had once got a start; the new shoots are 5 feet high, but there are no roses on them; one of the other six died; the rest started again and did well. The first rose opened July 25. Every plant had from three to five roses. There are some buds yet, but they will not open.

Of the chrysanthemums I have two growing, but there are no buds on them yet. On the dahlias the first flower opened August 15. I have a row of sweet peas along the south side of the house; they grew fine and are full of buds; in July about a dozen flowers opened, then the buds turned yellow, and I have not seen a flower on them since. The plants are still healthy looking and full of buds, but they will not open. I have seen them planted in other gardens and they were blooming all summer.

Dwarf nasturtium, mignonette, poppies (double and mixed), marigold, aster, amaranth, zinnia, and sweet alyssum did well, blooming since August 1. Daisies and pansies have been blooming all summer. Carnation, wallflower, and four o'clocks made good plants, but will only flower the second year. Double balsam are no good to raise in the garden; they are better indoors.

H. D. Clark, Skagway, Alaska.—I am glad to be able to report a better season for myself and other Skagway agriculturists than last year.

The report of my potato crop in the Daily Alaskan was not exaggerated. I planted 3½ acres of land to Early Ohio, White Ohio, Early Michigan, and Vermont Gold Coin potatoes. With the exception of the White Ohios our potato crop was a better one than I have ever seen either here or in the States. I have tried the White Ohio for three years in a small way, and I shall have nothing more to do with them. While the original potato which I used for seed was a very fine potato in every way, the potatoes raised from them have never been satisfactory either in quality or quantity. The Early or Red Ohio potato has been very satisfactory with us. I have raised it here for the past six seasons and have always been able to begin marketing in July; this season I began July 19. The Early Michigan, while not as early a potato as the Ohio, gives better satisfaction to the general market than the Early Ohio. I have raised it for four seasons and consider it one of the best varieties for this place. It is smooth skinned, white, mealy, and dry when cooked. Last winter I purchased 210 pounds of Alaska-grown Gold Coin potatoes. They planted a plat of ground measuring just 36⅐ square rods. This fall the crop dug from that plat lacked 40 pounds of being 4 tons, which is a yield of 576 bushels to the acre. The Gold Coin is a late potato, but it fully matures in this climate. It is white, mealy, and very fine flavored. With us it is of good size, no overgrown ones, and few small ones. The large yield results from there being so many in a hill. Mr. Hogan, one of our neighbors, had on a small scale a greater experience with Gold Coin than I. From five hills in his little garden he raised 55 pounds. They were very large potatoes, and he pronounced them of poor quality. The largest hill that we weighed in our patch weighed 7¾ pounds. Our other varieties of potatoes have always been somewhat affected with blight, or stem rot, but we found the Gold Coin so far absolutely free from it. From the 3½ acres of different varieties of potatoes I raised a few more than 1,000 bushels.

We set out about 3½ acres of cabbages. The cabbage maggot damaged them to such an extent that we got very unsatisfactory returns. When I found the maggot was so bad we cleaned the soil away from the stem and applied air-slaked lime. While it checked them somewhat, it was not a satisfactory remedy. This same maggot ruined all our outdoor radishes and turnips.

I raised about a fourth of an acre of carrots, which were of fine quality, very large, and the yield was enormous.

I did not pay much attention to celery this year, but there was some very fine raised in Skagway this year. Our neighbor, Mr. Wildt, raised a patch of the finest celery I have ever seen.

We set out the nursery stock which we received from you last spring and gave it the best of care, but find that only a part of it has grown or is alive this fall. The live plants consist now of 2 apple, 2 cherry, 2 currant, and 1 raspberry. What the story will be next spring time will tell.

We have been experimenting with tame currants and red raspberries for the past few years and find that they do well. We set out 300 of the Cuthbert raspberries last August and expect to set out several other varieties next spring.

I can not close without speaking of the great crop of wild berries which grew on the hills and in the valley around Skagway this year. First in season came the currants, then the red raspberry, then blueberries (or huckleberries) and the high-bush cranberry. There were bushels of these berries picked, and bushels of them went to waste. The cranberries are largely used in making catsup, which seems to be fully as popular as the tomato catsup, which it closely resembles.

Skagway's flower gardens grow more numerous and finer every year. There has been no snow or weather colder than 26° above zero as yet, and the pansies are still blossoming out of doors, though somewhat spoiled by the rains.

James Germansen, Kayak, Alaska.—I want to thank you for the seed you sent us at Middleton Island. You must excuse us for not reporting to you our success. We have had no mail facilities. We were bottled up on Middleton Island one year and twenty days, and all the news we received was from the whaler *Monteray*. We had no way but a small canoe to come to the mainland. We ran out of provisions, and starvation was staring us in the face. Finally the whalers gave us a little "grub" to tide us over until we could hear from the mainland. My partner and I have located a ranch apiece, but if we can't get any mail we are going to leave the island.

We have dumped tons of potatoes on the ocean beach just to make a little more mud. The same potatoes are selling at Catella for 3½ cents per pound. Middleton Island is the finest island in Alaska. We are past experimenting. We can raise anything they can raise in the Temperate Zone. Last summer we gathered 4 pounds of ruta-baga seed from volunteers we left in the garden all winter. Our cabbage has grown all winter in the garden. The coldest we have seen since we have been on the island was 20° above zero, the warmest 71° above. The deepest snow we have had was 14 inches. It lasted twenty days. Last winter we had no snow. The grass was green all winter. Middleton Island is the finest stock island in Alaska, but unfortunately from 45 to 60 miles from the nearest islands. But we have no harbor where we can leave a boat. It would be only 35 miles out of the regular route of the steamers. If we could get seven mails a year we could get along nicely. We have not been able to raise any carrot, beet, or onion seed. We want some Garnet Chilli potatoes, pure seed, for late potatoes. We could furnish this part of Alaska with potatoes if we had transportation.

Fred Liljegren, Little Naked Island, Prince William Sound.—Having the seeds and plants you so kindly sent me this spring, I will therefore let you know the results.

Apple grafts, apple seedlings, currants, and raspberries all took root nicely, except one Strawberry apple and one Charlimoff apple graft that died.

Stone Mason and Early Flat Dutch cabbage, set out May 19, made good solid heads, the first variety named being the largest. There being no frost yet I still keep them in the ground.

Curled Scotch kale grew to about 2 feet in height and was fine, dark, and tender.

Early Snowball cauliflower headed nicely. Peas, American Wonder and Pacific Early Market, planted May 13, did splendidly, the vines averaging 4 feet and the pods being large and well filled.

Half Long Stumprooted carrots did very well, some being 2½ inches in diameter.

I planted some parsnip seed, but they did not come up.

Ruta-bagas and beets proved a failure with me this year, as they mostly went to seed.

I tried several varieties of lettuce and radishes, and they all did very well. I also planted some potatoes May 10. The latter part of July we commenced to use them. I have just dug them, and we prefer them to those brought from Puget Sound, as they are more mealy.

I have sown a small quantity of barley each year for the last three years. Last year wind and rain laid it to the ground, but I cut the heads and dried them indoors and tried again this year. The grain ripened nicely.

Mrs. J. Garigan, Valdez, Alaska.—Most of the nursery stock you sent me is doing well. I have ten apple trees and one seedling which are 25 inches high. Of the six currants one is 32 inches high, and four of the raspberries are growing rapidly.

Beets (Detroit Dark Red) were a disappointment this year, as they went to seed very early; but carrots (Early Scarlet Horn) grew to medium size. Onions (Extra Early Brown Spanish) were fit for table use early in August. Broccoli (Mammoth White) was killed by late frosts, while cabbage (Early Jersey Wakefield) wilted a little, but pulled through. White turnips I do not plant, as they do not keep as well as the yellow turnip.

Sweet alyssum blooms early and more profusely than other annuals.

G. S. Clevenger, Copper Center, Alaska.—I sowed last spring 6 acres of oats, of which 4 acres was on a flat about 20 feet above the Copper River. These I put in with the drill and rolled the ground carefully afterwards. I cut about 2½ tons of good oats hay from this piece. The oats were nearly ripe when I cut them. I put in 2 acres on a high beach and broadcasted them and rolled them after sowing. These were not worth cutting. This was wholly new ground that had been burned over years ago, and the soil appeared to be good. Of the 4 acres first mentioned, 2 acres were new and the other 2 had been plowed once before. The plowing was all done in the spring.

I raised what might be termed a good garden. I had no potatoes to plant. I raised peas, onions, carrots, parsnips, ruta-bagas, lettuce, radishes, and cabbage. The growth was luxuriant. Some said it was the best garden they had ever seen in Alaska. My garden plat is 50 by 100 feet. I put ashes in the furrows before dropping the seeds, and it certainly did work well. I noticed on the field that wherever there had been a log pile burned there was a luxuriant growth of grain. I found the same thing was true on the experimental farm. I noted also the fact that the old land on United States experimental farm did not produce well. All this has forced the conviction upon me that the difficulty in raising crops here does not lie primarily in either the drought or frost, but in the fact that there is some element lacking in the soil. I did not water my garden, and the growth was excellent.

I have my cow and a 2-year-old heifer this winter. It is nearly two years since the cow was fresh, and we have our milk and make butter sufficient for the family. The cows will not be fresh until March. I think the smaller cows, that give very rich milk and are easily kept, are the cows for this country. It does not pay to raise beef here and will not for years. It can be driven in cheaper. Butter and milk is what is absolutely needed.

I brought three Wyandotte hens and a rooster in with me. They have done well. The hens have been great layers. I raised a half dozen chickens. We never had chickens do better. We can keep a dozen at little or no expense.

A. L. Hills, Seward, Alaska.—In compliance with your request I herewith hand you a report of my success with agricultural seeds furnished me by your Department.

I wish to note, in the first place, that the land on the 1st of January last was covered with heavy timber and moss. As soon as the frost was out of the ground I commenced grubbing the roots out of the ground. I planted two rows of peas 40 feet long, from which I gathered fully 2 bushels of peas in the pod.

I grew three crops of radishes on the same ground, and all were sound, crisp, sweet, and tender. Lettuce never tasted better than that grown here.

It lasted longer in its tender state than that which is grown in the States. Parsley was as fine as that raised in any country. Broccoli is as good as anyone could desire. Beets did not do well, but I think it was on account of the seeds being old. Carrots did well. Cabbage did as well as could have been expected; I was not able to plant them until very late. Cauliflower as fine as anyone need want was grown. Many cones or heads were 8 inches in diameter. Ruta-bagas grew very fine; roots 4 to 6 inches in diameter, tender and firm. Turnips never grew finer. In fact, for my own use I do not want turnips so large as some I have grown. Many of them are 8 to 10 inches in diameter, but they are solid and crisp. Onions were planted late, but I have many bulbs as large as half dollars. The celery was planted late, but did well. The parsnip seed did not germinate. I had the same experience with one paper of onions and one of beets.

In reference to the clover, I should say that this is the home of clover, either red or white. I see no reason why in the near future we should not be shipping forage instead of buying it, as we now do.

Potatoes do well, but I am of the opinion that they will mature better in the interior than they do on the coast.

Herman Stetler, Seward, Alaska.—Your favor January 18, 1905, received, also the seed you sent me, for which I thank you. The country in which I live is nearly all timbered. There is very little grass land, as it is a mountainous country and we have only creek bottoms to cultivate. It can not be made into dairy farms. It rains much more here than on the coast. There is some pasture over the foothills and mountain sides, but of the kind that grows in timber. There are no trails through the country and the river is too swift for use. My provisions cost me at least 10 cents per pound at my home. Produce shipped out would cost as much.

My garden did well this year. One ton of potatoes were produced from 800 plants. Carrots, Scarlet Horn variety, did well. Ruta-bagas, parsnips, and turnips did well; beets, Bassano variety, did well; kale, Scotch and Siberia varieties, did well and will winter with little care. Cabbage, Flat Dutch variety, did not do very well; it was too late. Onions, beans, and cucumbers are failures. I raised my own turnip, parsnip, and radish seeds this year. My peas did well.

F. Martin, Sunrise, Alaska.—The apple trees you so kindly sent me last spring have done fairly well. The grafted trees made but a few inches growth of new wood, but the seedlings grew very swiftly and made about 9 inches of growth. The raspberry and currant bushes did well, and I expect fruit from them next year.

The clover seed came up and made a good stand. This winter will prove whether it will winterkill or not.

A. Lawson, Sunrise, Alaska.—Many thanks for the packages of seed just received and also for the seedlings and berry bushes you sent me last spring. Every one of these bushes rooted nicely and they have made quite satisfactory growth.

The past summer has been very favorable for the various vegetables, and as a consequence I have a fine lot of potatoes, cabbage, turnips, beets, onions, carrots, parsnips, and winter radishes. I had an abundant crop of lettuce, radishes, spinach, parsley, cress, and flowers, and I took a good crop off my rhubarb plants. The potatoes in particular are solid and mealy; they grew quite large in size and the yield was as large as any previous year. This is the first season that my onions raised from seed have attained marketable size, but hereafter I feel reasonably certain of raising good onions in my garden.

Owing to sickness during the planting season and to the fact that I could not secure any help, I could only utilize a fraction of my cultivated ground. Had to abandon the grain crop, which otherwise would have been the most interesting part of my efforts.

Henry S. Tibbey, Coal Harbor, Unga Island, Alaska.—I again thank you for the various slips and cuttings you sent me in the spring. Allow me to report that of the apple slips four took root and made about 4 to 6 inches growth. Of the currant two took root, did well, and grew at least 2 feet. Of the raspberries four took root and reached about a foot above the ground. None of the rest made any sign and declined to be reported. The encouraging success met with in the case of the berries tempts me to ask for a further donation next spring.

Edwin E. Sholin, Jarvis City, Alaska.—In acknowledgment of the seed we received I shall first state that we did not receive it till the 1st of June, which was very late. Notwithstanding this we are having good results.

The radishes (Improved Chartier) are of the best quality and grow the largest of any I have ever seen. Lettuce (Hanson) is also fine. Turnips (Purple-Top White Globe and Purple-Top Strap-Leaf) did well. Ruta-baga (Thorburn Improved) and mustard (Ostrich Plume) are growing splendidly. Cabbage (Early Flat Dutch) and onions (Extra Early Brown Spanish) were planted late but they are doing well. The peas (Marblehead Mammoth) are growing splendidly and beginning to bud. The beets (Dirigo) grew very poorly, and the beans (Improved Golden Wax) came up, but would not grow, and soon died.

The flower seeds came too late to be planted this season. They will be planted this fall or next spring.

I will also mention that potatoes grow splendidly here, and that I believe that carrots, parsnips, and other vegetables will do well in this locality.

A. W. Newhall, Unalaska, Alaska.—The seeds sent out by the Department of Agriculture were received and planted in due time. Owing to the warm summer and also to the moderate rainfall the garden has done well—better than any previous year. The kale, lettuce, and radishes grew rapidly. The turnip crop was a good one, some of the turnips measuring 24½ inches in circumference. Rhubarb also does well in this place. This season I have also planted a few strawberry plants.

Mrs. T. D. Elliott, Council City, Alaska.—I put out a garden this spring on June 4, but did not have very good success. I do not know whether it was the fault of the seeds or the cold weather. The lettuce was the only vegetable that was fit to use. The beets, radishes, and turnips went right to seed. There was not a garden in Council that amounted to much. I shall try again next spring and hope to have better success.

S. A. Shea, Council City, Alaska.—I send you my report on vegetables growing here. On June 6 radishes, turnips, kale, spinach, onions, cabbage, ruta-bagas, mustard, potatoes, peas, beets, parsnips, and carrots were all up doing well. June 21 we had a flood here. The water came over my vegetables and ruined all. I planted over again and have good turnips and cabbage. Lettuce, onions, beets, and ruta-bagas are small. Next spring I will try again.

I have sent to New York for seed. Thanks for the seed you sent me. We have had a cold summer, ice in August. To-day ice is 1 inch thick. I have 2 acres of land in cultivation.

Mrs. A. V. Dedrick, Council City, Alaska.—Will you please send as many seeds, both flower and vegetable, as possible? I have tried some of the Government seed for the last three years with very good results. This season has been very wet and cold, not more than six sunny days in all. But I have small cabbages, turnips, kale, spinach, mustard, radishes, lettuce, parsley, and beets. Beets and onions are both very small. Parsnips and carrots were a failure, but everything else is doing well. Peas and beans were too late in coming to plant this year.

As for my flowers, I have a bank of double poppies of all colors 4 feet wide and 11 feet long growing from one package of seed. Nasturtiums did well, growing 4 feet high; plenty of blossoms came out, but an early frost killed them. Sweet peas are budded, but I am afraid they will not bloom. All the flowers were grown in new ground, a mixture of loam and beach gravel with very little manure.

I tried two kinds of radishes. The Early French Breakfast was the best, maturing in twenty-nine days in a light sandy soil. I tried one bed with manure, but they ran to tops. The long radish did not do so well; it was six weeks before it was ready for the table and then it was tough. Turnips, Purple-Top Strap-Leaf, has been the best. I burnt over the chip yard in the spring, turned the ground, put in a little manure, and sowed the seeds broadcast. We thinned them well, using the tops for greens, and they have done much better than those in the garden. I asked for a quantity of seeds, as we have about fifty natives here during the summer. They are all very much interested in the garden. I gave seeds to three of the younger men, and they all have fair gardens. Next year, with the experience of this, I think they will do well enough to have something to sell. They are an industrious, good, capable people, and I think once started would do very well with gardens here, as there is a demand for all kinds of garden stuff and high prices paid for it.

One boy brought me a nasturtium blossom as large as the top of a tumbler, and having eight petals instead of five. I had told him about using the offal of the squirrels and the bones—of which they had a good deal after the spring catch—as fertilizer; so when he planted his flower seed he put two seeds inside of a dead squirrel and planted it. They were longer in coming up than the others, but I think all the blossoms are double, like the one he brought.

I think it would be very easy to raise strawberries, as there is plenty of good sandy soil. Last year I sent out for some plants, but they came in after the boats had stopped running between Golovin and Nome. They were a long time reaching me, but we packed them in sand and stored them in the cellar till spring. I saved only a few plants, but they have done well, although it is too cold for the berries to ripen. The native red currant pays well for transplanting; it yields double the next year.

I also have good results from bulbs, and we have plenty of flowers in the house all winter. Pansies do the best of anything. I have some plants that are 3 years old, and one has borne over 300 blossoms this year. I cut them down every fall, put them in the cellar till April, and set them out in the garden as soon as it is warm enough. I hope you will be able to let me have plenty of seeds, for home use as well as for distribution, as early as possible.

Vegetables grown at Council City, Alaska, during the summer of 1903 are shown in Plate VIII.

Correspondent, Holy Cross Mission, Alaska.—Last year I told you that our crops were not as satisfactory as usual, and this year I can say so with greater reason, owing to our very short and cold season.

We had very cold weather and rain most of the time till the middle of July; then a few warm days and sunshine, followed by dark, cold weather again. Hard frost in the beginning of September put an end to all growth; still we left our crops out till September 13. We were expecting a few days of sunshine to dry our potatoes before bringing them in, but finally had to take them out the best we could; the ground being already frozen pretty hard on the top, it was not safe to wait longer.

What I can not understand is that nearly everything grew to seed this year—turnips, ruta-bagas, beets, celery, onions, etc. In past years only the beets grew to seed. The turnip field was a mass of yellow flowers. I should be very thankful to know the cause of vegetables going to seed before their time.

I raised some parsnips and onions under glass, and transplanted to open ground in June. These did fairly well. I succeeded better with celery this year, as it had an early start indoors in the beginning of April. Most of the celery measured 3 feet in length and 7 inches in circumference at its thickest, near the root. What grew to seed measured 4 feet. I tried tomatoes again, but after transplanting they did not even produce blossoms. I have fresh seed of an early variety, and I mean to try again. I may hit sometime on a warm season and astonish everybody. We had a few ripe strawberries in the beginning of August, but they had been in blossom from the 1st of June and could not ripen for want of sunshine. The carrots were poorer than usual. As I mentioned in my last letter, our cucumber and melons melted away by some kind of invisible frost the first week of July. Different varieties of oats, barley, wheat, etc., were tried.

I am happy to acknowledge the receipt of a good supply for next year's trial. I distributed a good deal of it among the Indians, especially turnip, radish, and onion seed.

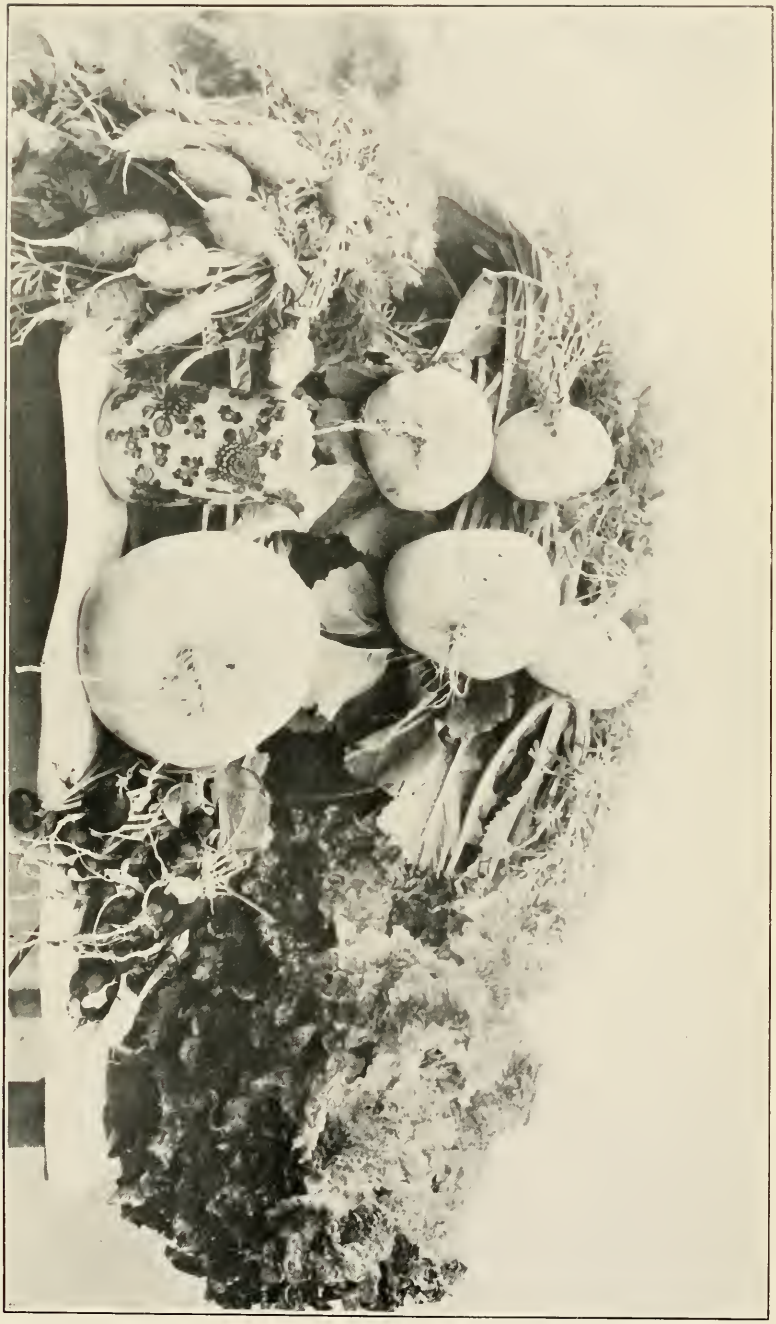
In the beginning of July I received by mail a few pounds of shallots, and I planted them immediately under glass, to try and have them mature before autumn. They grew rapidly to a good size. But I am not sure that they are ripe enough to keep over winter.

John W. Chapman, Anvik, Alaska. It gives me pleasure to acknowledge receipt of a shipment of seeds from your office, by mail, for various native and white residents of Anvik. These have been delivered and have been gladly received.

The season has been a rather cold one, and all crops are already housed. Potatoes are of excellent quality, and average rather larger in size than last year. The carrots and beets are also better than last year. Rhubarb was perfectly successful. Onions, overlooked and left in the ground last year, renewed their growth in the spring, but did not attain to any great size. Onions from seed grew to about three-fourths of an inch in diameter. The flowers that gave the most pleasure were stocks, clarkias, nemophilas, poppies, and sweet william. The last did not mature last year, but plants left in the ground proved hardy and grew into fine flowering plants in August of this year. Pansies should have been included also in this list. They survived the winter and did exceedingly well, some of the blooms measuring 3 inches in diameter. Chinese pinks wintered, but failed to blossom, although they were full of buds and needed but a few more days to reach perfection. In a better location they would doubtless have proven successful.

A cow and a calf were imported for the mission, reaching us the last week in July. Ten tons of hay were cut along the margin of the Anvik River and stored for the winter at a cost of less than $100. The expense should be much less next year, as the ground had not been prepared for cutting the hay. The experiment of keeping a cow must be regarded so far as successful, for in the month and a half that we have had her she has given us more than her own weight in milk—on the native forage.

W. Wenrich, Chena, Alaska.—Carrots planted May 18 in soil cultivated for



VEGETABLES GROWN AT COUNCIL CITY BY MRS. C. B. PHILLIPS.

two years and manured both years were ready for use the last of August; were pulled September 20, being from 2½ to 3½ inches in diameter and very nice. I transplanted some, but they did not do very well.

Onions: Seed sown May 15. Grew slowly and were as big as marbles by August 15, but did not grow much after that time. The soil was well manured, Those planted May 24 did better than the ones of May 15.

Cabbage: Seed put in May 15; transplanted June 12; ready for use from September 1 to 15; pulled September 21. About three-fourths of it headed up, the heads averaging about 2½ pounds. Cabbage planted April 22 in boxes and set out May 31 developed by August 20 to 30. Mostly all headed well, weighing 2 and 3 pounds. The soil was previously cultivated and was well manured the first year with horse manure and this spring with salmon offal. Most of the cabbage set out June 23 had small solid heads which averaged about 1½ pounds. Cabbage planted June 9 was too late to mature.

Carrots: Planted May 31, but were sowed too deep. They were about 1½ inches through, when dug, September 2.

Spinach: Planted May 17; ready for use in July; grew to a height of about 2½ feet and was very nice.

Beets: Seed sown May 15; transplanted June 17; became as large as small teacups, but they were woody, wormy, and scarcely fit to use. The ground in which they were planted was second-year ground and well manured. Beets planted May 5 replanted June 22 in the same soil were not as good. Those planted in new ground which had been well burned were small, but nicer than those in the richer soil.

Sweet peas: Planted May 16; bloomed beautifully in later August and September. I never saw such deep, vivid coloring in flowers as in these.

Ruta-bagas: Planted in rich soil cultivated two years May 17; grew to be 4 or 5 inches in diameter, but were inclined to be woody. Some which were planted in new-burned soil did not grow quite so large, but the roots were of better quality. These were replanted 8 inches apart. Ruta-bagas were sown broadcast June 9 in new-burned soil. Some grew as large as teacups, but most of them were a little too late, being planted too deeply. From experiments this year it seems that all roots did better in the new-burned soil and planted very shallow. Also that the ground spaded 6 to 8 inches deep did not produce as quickly by one week as ground barely turned over. The soil should be well pressed over the seeds.

Celery: Planted May 27 in a big box of rich soil; came up very thin and was left standing in the box. It had grown to about 2 feet high by fall.

Brussels sprouts: Planted May 22 in boxes; replanted June 4; grew about 1 foot high. We did not use them at all.

Parsnips: Planted May 22, and grew slowly. They were not over an inch thick September 1, and an inch and a half September 22. Those planted June 9, in new soil too deep, did not grow large enough to gather.

Turnips: Planted June 14, in new-burned soil. The ground was barely turned, the seeds planted shallow, and did well. They were 6 to 8 inches thick. These were planted at the right time for the fall crop; they would have done well for summer market.

Cauliflower: Planted April 22 in boxes in the house; replanted June 17; August 10, was heading, and well developed by August 20; the heads were 10 inches across. When not pulled the heads shot up into branches and spoiled.

Onion: Seed planted June 6, but was too late. Beans were planted June 6, but frosted August 14. Sweet corn planted June 9, grew 9 inches, and was frosted August 15.

Oats: Sown June 19 and headed out August 12, about 2½ feet high. It was planted on good soil and made good feed on October 1. A few seeds scattered around on the snow in the spring turned yellow before frost and the seed fell to the ground. We shall see if any of it turns up volunteer next spring.

Timothy: Seed scattered around in the fall of 1904 came up well and grew 2½ feet high this year, but last winter was very mild.

Millet: Seed sown July 5; grew 6 inches high, but was killed by frost August 22.

Potatoes: Planted June 23; 15 pounds of seed produced 75 pounds of very small potatoes. I shall keep part of this seed and try it in the spring.

I replanted wild raspberries June 26; July 27 I filled in and planted more—about 125 plants in all—and have cultivated them several times. I found wild berries ripe July 26, and they lasted till September 1. They grow in abundance on the hillsides, where the sun strikes them, and should respond to cultivation. I shall manure these next winter and cultivate them next summer.

I also took up and replanted about 50 plants of red and black currants; they are found wild along the small ravines and creeks. I am afraid the place I planted them in is too exposed, though I covered their roots well with grass mulch. Everything planted in the open field before May 10 did not do as well as a few days later.

September 30 I buried in holes 2 feet deep or more and covered 1 foot deep, heaping well on top, so as to drain in the spring, a few pounds of each of the following: Carrots, turnips, cabbage, beets, home-grown carrots, onions, potatoes, and ruta-bagas. I shall see how they winter and report it.

For two years I have had volunteer pansies.

Lettuce did very well, some heading up almost like cabbage, at least a foot across.

Radishes did well, but, like the other roots, did better in the new soil, which had a coat of 2 inches or more of ashes of burnt vegetation. In the rich soil the radishes were wormy, but not in the new soil. They grew 2 to 3 inches thick. I saved some radish seed pods, which I think are ripe enough to grow in the spring.

I brought in a few strawberry plants from Dawson, but they did not live. They have to be taken in in the fall in Dawson or most of them winterkill.

Rhubarb did well on a ranch above me this year, and I shall plant some next year.

Parsley grew very nicely all summer.

My soil was not flooded when Fairbanks and Chena were overflowed this season. It is high and dry, and I believe excellent potato soil. I expect to put in quite a piece next year.

This year was very rainy after July 1. Before that time we carried water for cabbage and cauliflower. Next year I shall try to irrigate with a water wheel, as the Tanana River runs past my place.

REPORTS FOR 1904.

The following letters, which refer to the season of 1904, were received too late for publication in the report for that year. They are printed here because many of them are of much value in that they give the reader a good insight in the prevailing conditions. The season of 1904 was backward and unfavorable in the coast region, but it was, on the contrary, quite favorable in the interior. The reports for 1905 are the reverse. The season was favorable in the coast region, while the results in the interior were not satisfactory, owing to more than the average amount of cold and wet weather.

Special attention is called to the following valuable report from Judge Howard, of Coldfoot. That vegetable growing can be made a success 60 miles north of the Arctic Circle is a fact which will interest all who are friends of Alaska. The further fact that potatoes have a market value of 30 cents per pound will suggest the possibility that a market garden might pay better than a fairly good gold mine. The price also gives a hint of the economic conditions which exist, and, inferentially, the need of roads and transportation facilities.

Frank E. Howard, United States commissioner, Coldfoot, Alaska.—In reply to your request that I report results of my efforts at gardening in this section of Alaska during 1904, I submit the following:

Coldfoot is situated near the head of the Middle Fork of the Koyukuk River, 67° 20′ north and 150° 20′ west, about 60 miles above the Arctic Circle.

In the spring several small gardens were planted in Coldfoot and on the adjacent creeks from seed sent me from your Department. But I shall report the results from my garden only and the prolific crop of the one that was planted by our deputy marshal, J. H. Johnson.

The summer of 1904 was the third planting of my patch No. 1. The soil has proven not as prolific as my other patches, owing to its being clayey and retaining the cold. It is slow to thaw in the spring, and when I spade it up about May 1 the shovel touches frozen ground at a depth of from 6 to 8 inches. When I first cleared this patch it was covered with a foot of moss, and my experience leads me to the conclusion that moss-covered ground, for some years at least, is decidedly unfavorable to garden growths. At least ground that was not covered with moss produced far better results. For three seasons patch No. 1 has produced a fair crop of turnips, with an increase of worms each year that did some damage. The turnips planted were Purple-Top Strap-Leaf, and White Milan. Yellow Goldenball turnips did fairly well, and I think in more favorable ground would produce excellent results. They are the best turnips for winter storage. Ruta-bagas were a failure. Lettuce (Boston Market) did fairly well. Radishes were destroyed by the worms. On May 12 I transplanted cabbages (Early York) when the plants were 2 to 3 inches high. As a protection from freezing nights, occurring at intervals up to June 1, I covered the plants with white-glass beer bottles, first cutting off the bottoms and necks. In such jackets the plants flourished well, and by June 10 had grown to such size as to fill the bottles, when I uncovered them. Most of these plants headed to about the size of a cocoanut, many of them being quite solid. I harvested my crop the first week in September, and have cabbages for all winter and a keg of fine sauerkraut.

My experience during two seasons with patch No. 1 led me to believe that garden stuff would grow here with some degree of luxuriance in more favorable ground. I therefore selected a patch almost free from the usual heavy covering of moss, cleared it in the first week in May, spaded it the third week, and planted lettuce, radishes, peas, beets, ruta-bagas, and turnips the last week. About June 1 I transplanted a bed of kale when plants were 2 inches high.

Lettuce (Boston Market) I planted in two remote beds. One bed was a complete failure, but the other one produced abundantly in large and exceedingly fine heads, tender and sweet. Such a contrast in the growths from the same seed in practically the same soil I can not account for. Radishes (a globe-shaped variety) could not be excelled, as also the White Milan turnips. Beets (Crimson Globe) grew to goose-egg size, tender and sweet. The tops were large enough to make excellent greens. I believe that with careful attention a reasonably good crop could be raised. Peas grew from 2 to 3 feet high, blossomed and podded abundantly, but were killed by frost before they reached edible size.

Kale grew from 2 to 2½ feet high. When the ground began to freeze I pulled the plants and stored them for winter greens. They keep well as long as they remain frozen.

I had four very small potatoes, which I cut in half and planted in eight hills. They sprouted quickly, and produced healthy vines that blossomed and yielded a crop that was a pleasant surprise. The one-half pound of seed potatoes, probably less, yielded 28 pounds of average-sized tubers, some being quite large, and I never before ate potatoes that tasted quite so delicious. Now it is a question whether or not these potatoes matured. They show eyes, but faintly. I shall plant some of them next season and settle the question. I should like to known the particular variety of this potato, since it has proven so adaptable to this climtate. They were shipped by the Northern Commercial Company to Bettles in the summer of 1903 as market potatoes. The result of this magnificent crop is that some full crates of potatoes are being carefully wrapped in blankets and stored for next spring's planting. I have cleared a new patch of ground with fine sandy loam to plant a full crate. I might add the price of fresh potatoes in Coldfoot is 30 cents per pound, and the supply scarce. The result of my crop was 56 pounds to 1 pound of seed potatoes. From one crate (100 pounds) I can expect a crop of 5,600 pounds; value, $1,680. Potato raising 60 miles above the Arctic Circle looks quite alluring.

Ruta-bagas in patch No. 2 produced but little in the root line, but supplied the town with greens with their abundant growth of tops, that remained tender until damaged by successive frost.

During June and the first week in July my meteorological record gives only four "traces" of rainfall. Therefore during that period I watered my garden two or three times per week.

I have a cellar underneath the floor of my office room filled with turnips and ruta-bagas, and a winter supply of cabbage and kale in my cache. Therefore I can say that gardening in this section of Alaska is a lucrative industry.

The garden of our deputy marshal excelled my own in point of crop, especially in ruta-bagas and turnips. The largest turnip, a White Milan, weighed 5½ pounds and was 25 inches in circumference. Turnips weighing 4 and 5 pounds were quite common. Carrots (Scarlet Horn) did fairly well, some being 4 and 5 inches in length. Parsnips did fairly well. Beets made a good showing, with indications that with careful training and attention a reasonably good crop could be raised.

This garden was cleared and manured in the spring and immediately planted in its first year. It is a rich, sandy loam several feet in thickness, with an underlying stratum of very dry sand and gravel, and is termed "not frozen" ground. Years ago fires burned off all timber and moss, leaving the soil, it seems, in a perfect condition.

Henry A. Stade, Twelve-Mile-Road-House on Birch Creek, post-office Circle City, Alaska.—Last winter I wrote and asked you to send me a few seeds, which you very promptly did. They arrived in good time and in good condition. I shall give you my first year's experience in farming in Alaska:

I planted 700 pounds of potatoes, commencing on the 1st day of May, 1904, and planted some as late as the first of June, on ground which I cleared during May. I was surprised this fall to see that the last planting was just as large and good as the first. I harvested in all 20 tons of potatoes, for which I have a ready market at $11 per 100 pounds. Next I planted four papers of Scarlet Horn Carrots. They were the largest and best that anyone ever saw in this country. Some of them were three inches across the top end. I raised 900 pounds in all, and sold them at 15 cents per pound. I planted four papers of parsnips of the Early Round variety. These were as fine and large as the carrots, but I raised only 300 pounds. They sell for 25 cents per pound. I planted four papers of Crimson Globe beets. They also grew to perfection. Some of them weighed 4 pounds, and in all I gathered 620 pounds. These sell at 25 cents per pound. I also planted four papers of turnips of the White Flat Strap-leaf and the Purple-top. Both kinds did well and grew to good size; the largest one weighed 10½ pounds; I gathered 1,500 pounds. I planted four papers of ruta-bagas, which did well; the largest weighed 12 pounds, but these did not yield as well as turnips by 200 pounds; they sell for 8 cents per pound. Four papers of Extra Early Brown Spanish onions came up well, but grew slowly and did not amount to much. Three papers of peas did well, and kept bearing till frost came, September 3. These seeds were all planted in open ground during the month of May.

I planted two papers of Stonemason cabbage and also one paper of cauliflower in the hothouse in April and transplanted them in June, but they did not do at all well. I also planted two papers of beans, select variety, and one Early Red Valentine, but neither of them matured. You will see that I did remarkably well, and I must say that farming in Alaska on a small scale is a success, and I have made more money this year farming than before in mining.

I must not forget to mention my radishes and lettuce, for they were the pride of the table all summer. Many thanks for the seed you sent me last spring, and also for that you also sent me this fall. As this was my first year farming, I am again without seed, but next spring I shall set out carrots, turnips, ruta-bagas, parsnips, and other vegetables and try and raise my own seed.

I will experiment with any seed you would like me to try, and I shall take great pleasure in doing so, for I do think the time is coming very fast when Alaska will produce her own vegetables of all kinds, probably not every year in all places, but when one place should fail the supply in another place would suffice.

A. A. Turnbarge, Fairbanks, Alaska.—I send you samples of grains in this mail which I raised this past season (1904) at this place. I took no pains at all with it, but scratched up a small patch on very poor soil, and also harvested it a little too early. I sowed it May 8 and harvested it August 15. The season was very backward, and we had two light frosts during the summer, but I am satisfied that grain will do all right here with fair attention. I did not put fertilizer on the soil. My vegetables were very good, considering the season and the attention given them. I sowed a little of everything for an experiment, and I am sure that in time this will be a farming and self-supporting district. I have sowed Alsike clover and timothy seeds, and will know if the winter is too severe for it by another season.

J. F. Karshner, Magic Hot Springs, Baker Creek Station, Alaska.—This year (1904) I have red currants, black currants, and red raspberries growing wild at my place, also the service berry, or cherry as some call it. I shall try each by cultivation and see what results follow.

When it came to taking care of my potatoes in the latter part of September I found plenty that would weigh from 1½ to 2 pounds; two weighed 3 pounds each. My grain did well. The wheat stooled to from 10 to 14 stalks, the barley from 8 to 12. I never saw grain do better; the grains were of a good size, and the heads were well filled. I shall try sweet corn, tomatoes, watermelons, and muskmelons this year. Celery did well. I shall make it a special crop in 1905. I must tell you of a variety of cabbage that did the best. The Government sent it to a neighbor, and I tried some of it at my place. It has a short solid head and is called Stonemason. I just had one paper for this year; it is a sure header for this place. So is the Jersey Wakefield, but it is not so large or heavy as the Stonemason.

Edgar Crompton, Tanana, Alaska.—The following are the results for 1904 of your seeds planted by me at my station on the banks of the Yukon, opposite the mouth of the Novikakat River, 6 miles above Kohrine's old post and 90 miles below Tanana:

Last year we dug up a considerable plat on a bench about 50 feet above the river and succeeded in raising a fair crop of turnips, carrots, and radishes, which were all the seeds we had to plant. This year nothing seemed to flourish there except the carrots, which yielded a very good crop.

This summer I was able to get a small plat dug and fenced alongside of our buildings in a willow bottom, which has been richly manured. Here everything seems to thrive to perfection, as, indeed, might be expected, as the place has a warm southern slope and the low hills serve as a break to the winds, which are very cold toward fall.

The flowers were grown beneath our cabin window in a small bed about 10 by 15 feet. I gave them more attention than anything else.

Peas (Prolific Early Market) were planted as soon as the ground was thawed sufficiently to dig it. They were well cultivated, but only watered a few times. They grew about 5 feet high, and yielded a very fine crop. I left some for seed, but the pods were still green when they froze.

Beans (Early Red Valentine) were planted at the same time as the peas and close by them. All rotted in the ground. Some others were planted a month later on a hill and yielded a small crop.

Parsnips (Early Round) were planted on the hill and grew about the size of carrots. I believe they will thrive in better soil. Beets (Crimson Globe) were planted on the hill. Most of them were very small. Spinach (Long Standing) did splendidly. We had more than we could use. They did not need watering. Radish (French Breakfast) grew to perfection everywhere it was planted, and was better than any of the other varieties planted. They did not require watering. Mustard (White London and Ostrich Plume) grew a good crop and was cut early in the spring for salad. Cress (Curled) grew a very heavy crop and sprouted up as fast as cut down. It was used all summer. Rhubarb—17 hardy young plants—has been set out in shape for next year.

Lettuce (Morse and California Cream Butter) was started early under cover and transplanted. Both varieties did well, but the latter seemed to me to surpass anything I ever saw before. We found it excellent when boiled like cabbage. Many people who saw them remarked that they never knew of any lettuce before having such huge solid heads. Carrots (Early Horn and Chantenay) were a heavy crop.

Phlox, shirley poppy, sweet alyssum, corn flower, sweet peas, candytuft, nemophila, nasturtium (Madam Gunter and Dwarf), and stocks all did well and bloomed till frost killed them. They were planted early, under cover. The stocks, poppies, and nasturtiums were most admired.

Correspondent, Holy Cross Mission, Alaska.—Last year's crop (1904) was about one-fourth less than the usual quantity. We had a long, cold, dry, and windy spell right after planting season, May 15 to 25, lasting till the beginning of July; then almost continual rain for about three weeks. We had very few real warm days.

The turnips and cabbage did fairly well, but the potatoes were very poor and watery. Barley, oats, and wheat were sown, but nothing matured. I took the greatest care of the new variety of Windsor beans you sent me, giving them the best spot in our little front garden, but the ground kept so cold that it took weeks for them to come above ground, and at frost, September 20, they were only beginning to form pods.

Toward the middle of August we transplanted some strawberry plants, both bush and running varieties. The plants were very strong and healthy. They had been raised in cold frames under glass and had already blossomed when put in the open ground, where they remained all winter with a slight protection of straw. All the running varieties stood the frost bravely, but nearly all the bush varieties perished. The former began to bloom in the beginning of June, but everything is now at a standstill on account of cold weather.

We had real May weather in the month of April. The snow had disappeared about the 15th of that month. The entire month of May was cold with the exception of a few days. We had snow as late as May 25, when most of our planting was over. Ever since that we have had constant rain and dark, cold, showery weather. On July 16 we had a hail shower. The strong winds almost uproot the young plants which are trying to push their way up. These two last summers are the coldest we have seen since we have been in Alaska. There are no two years alike.

I sowed some melons and cucumbers in the hotbeds, and they came up nicely and were doing well till I was obliged to remove the sashes on account of other plants. The air became too cold for their delicate natures. They stopped growing and turned yellow. I have some more cucumbers which I started June 10 in a hotbed by themselves, and they are doing well, but I am careful to keep the glass on at night. I have about 200 strong plants of celery about 7 inches high which I shall plant in trenches as soon as our first crop of radishes is finished, and that will be in a few days.

E. R. Brady, Wickersham, Alaska.—At this time we have prepared for cultivation upward of an acre, and last year Mr. J. R. Anderson, who owns and conducts a large roadhouse here, raised a fine crop of oats. At that time the ground was new, but this year he expects to have a still better crop. He is clearing more ground now, and by this fall we shall have perhaps 5 acres ready for use.

I have a small hotbed which has been in operation since March 20, and at this time has radishes, etc., almost ready for use. This has been a very cold spring in this section, but we hope to have it warm from now until fall. The rainfall here is about the average for the Yukon Valley.

The soil in this section of the country is the same as I have found in all parts of the interior of Alaska. It is of a sandy nature, with some black loam and yellow clay. After the removal of the vegetable growth it is very mellow, and the second year it will produce fine crops. I have never planted anything in this country that did not prove entirely satisfactory. But it may be that I gave more attention to my work than a person would who plans for commercial returns.

The number of acres available for cultivation, or for pasturage, I can not estimate, for many sections of the Forty-mile district are yet unexplored. However, the Mosquito Fork of the Forty-mile is almost entirely good agricultural land. It is about 5 miles wide on an average and about 40 long. This is estimated. Also the Dennison Fork of the same river is as large and of the same character. A number of homesteads have been taken on the Mosquito Fork. There was a large quantity of wild hay harvested on the Mosquito Fork this last year. One farmer has a mowing machine, rake, etc., and he expects to cut more this year.

[Attention is called to the foregoing description of the valley of Mosquito Fork. It has long been known as an extensive natural meadow, and according to all reports the soil is well adapted to cultivation. In the report for 1901 Mr. Isaac Jones gave a more general description of that portion of the Forty-mile country, which borders on the Eagle-Valdez trail, and then estimated that there were 750,000 acres available for agriculture and pasturage in the valleys of the various branches of the Forty-mile and the Ketchem stock flats. Until a railroad shall penetrate this region it is practically inaccessible.]

Joseph L. Braxton, Tanana Crossing, Alaska.—I have started to farm in the Tanana Valley, and I write for some seed as well as for some information as to what will grow here. We nave a fine climate and very good soil. I started to clear off land last July (1904) and I think I shall have 10 acres this spring ready for the plow. I have a cabin 18 by 24 feet, inside measure, and a stable 12 by 18 feet. The only drawback I find is that it costs so much to live and get farm implements. I pay $50 or $60 for flour and $50 per 100 for rice and beans; $75 per 100 for bacon. I should be pleased to hear from the station at any time, and any seed you send will be highly appreciated.

[Tanana Crossing is on the Eagle-Valdez trail, north of the Copper River Valley.]

Adolf Stecker, superintendent Moravian Mission, Bethel, Alaska.—Concerning our garden, we are happy to report good success. In early spring (1904) I worked much in the garden, but it paid me well. We raised the plants in hotbeds first and set them out in the middle of June. Potatoes were planted in the ground May 28 and harvested September 22. While those raised from potatoes brought from the States were good, but small, those we grew from seed raised here last year were large and very good. On one plant we counted 14 potatoes, the largest the size of my fist, the smallest the size of hen eggs.

Cabbage, cauliflower, kale, ruta-bagas, radishes, and turnips did very well. We also had very nice flowers—pansies, stock, cornflower, and others. Everyone who saw our garden wondered at it, and Mrs. Stecker and myself have had much enjoyment in seeing everything do so well.

About 100 yards west of our station is a lake, and in the spring I started a garden there. The ground was all covered with moss, which I removed. I found under it about 6 inches of soil and below that was sand. I put out some potatoes, cabbage, ruta-bagas, and turnips there. The turnips came up in very short time, but they withered away. The cabbage and ruta-baga plants looked fine and green at first, but did not grow, and are now almost as when we put them out. The potatoes grew a little.

If we were only a few miles farther up the river among the trees it would be much better. I went with some Finns up a mountain stream, and there we found some most excellent land. Grass on both sides of the river grew 5 feet high. The Finns thought it a pity that such beautiful land was not used for farming, and that is my opinion, too.

Joseph Kahlen, Carmel, Nushagak River, Alaska.—The months of June and July (1904) were most delightful; August and September were rather wet. Winter set in by the middle of October, but so far has not been unpleasant at all. I could not always find out the actual snowfall; it often seems to snow when it does not. The air is at times filled with particles of snow carried along by a strong wind and drifting in all directions.

Our gardens have done fairly well. We had a fair crop of good potatoes and exceptionally fine cauliflower. Rhubarb, kale, turnips, cabbage, carrots, ruta-bagas, and radishes did fairly well.

Mr. Rock had planted some rye; it grew to a normal height, but the seed did not mature; it turned black. Peas stood in bloom for a long time; they formed pods, but the peas did not ripen. We keep two cows, a calf, and a horse. We have in places a luxuriant growth of nutritious grasses, and our stock can support itself during the summer. Our supply of hay was cut after the first frost had set in.

In July we tried a new incubator sent us from Philadelphia. Mr. Rock put in 50 eggs, of which number 17 were hatched. It was rather late in the season, much wet weather followed, and only four of the chicks survived. A few of our hens began to lay about the middle of November.

I came here on the last day of May. Shortly afterwards I began cultivating a small piece of land and had the satisfaction of raising a good crop of radishes, kale, and a fairly good supply of fine turnips.

Last summer we made a trip up the Wood River to the lakes and were delighted at the beautiful scenery and luxuriant character of the vegetation. It is a magnificent timber region, in sharp contrast with the treeless region of the lower Nushagak. This lake country will make an excellent grazing country for reindeer.

Elizabeth Schwab, Jesse Lee Home, Unalaska, Alaska.—Your package of seed came to-day, reminding me that I had not as yet given you any of my experience with last year's (1904) seed. Last spring was very late and the summer was cool. I started cabbage in tin cans in March, transplanting them in the latter part of May, and succeeded in having some small heads ready for the table late in September. We have had such nice lettuce and greens. The beets not growing very large, we used the tops for greens. They were nicer than spinach. We started some rhubarb in the hotbed last year and it grew to 2 feet. We transplanted it into the garden this year and inclosed it in boxes. I was afraid it would spoil, as we tried transplanting it before, but the boxes preserved it from its enemies and it was well manured with chicken manure.

I can not tell how the children enjoyed the turnips and ruta-bagas from their gardens and what a blessing and health-preserving benefit our garden is to our flock.

We have also used much of the flower seed. Sweet peas, sweet alyssum, stocks, and many other flowers make our home more beautiful and give their joy and gladness.

Alexander Friedolin, Afognak, Alaska.—I have sown the seeds I received from you as follows:

Cauliflower and cabbage were planted in the box April 14, 1904, transplanted to open ground June 2. I planted turnips, onion sets, and sowed cabbage, kale, celery, radishes, and salsify in open ground on May 11, and transplanted kale and cabbage on June 2. I sowed Romanow wheat, Swedish Select oats, and Manchuria barley, all imported seeds, on May 12. I sowed flowers, ruta-bagas, peas, and cauliflower on May 12 and transplanted the cauliflower June 2. I planted potatoes May 17 and 27. Onions (Extra Early Brown Spanish), beets (Crimson Globe), carrots (Scarlet Horn), ruta-baga (Champion), turnip (White Strap-leaf), parsnip (Early Round), parsley (Early Curled), and radish (French Breakfast), were all sown on May 21. Lettuce and dill were sowed May 29. The result was unsatisfactory this year. The potatoes were fair. The turnips turned out to be excellent, as also did the ruta-bagas. Radishes, kale, rhubarb, cauliflower, lettuce, and garden flowers were partially a success.

As the packages you sent us contained no cabbage seed, I had to use old seeds, a late variety, and they are growing yet with big leaves and no heads. All vegetables except those mentioned above were a total failure. The season was not favorable, and being away from home nearly the whole summer trying to earn my living somewhere else, I had no opportunity to give them proper attention; hence the failure.

I commenced to take up vegetables, with the exception of cabbage and kale, September 29 and had them all in the cellar by October 1. Romanow wheat is in the milk yet and still growing. Manchuria barley and Swedish Select oats were sowed late and in a cold ground. They are nearly matured, especially the former, although the straw is green yet. The winter wheat and rye matured all right. The heads of rye are not full. They have few seeds, but the wheat is better. I sowed winter wheat and rye in the latter part of August last year. They came up and grew satisfactorily and were of a right height when snow covered them before frost, but early in the spring the snow left the ground and the plants were left exposed, after which we had frost and rain intermittently.

In your report for 1903 you have come to the conclusion that grain can not be grown successfully along the coast. However, I believe that certain grains can be grown successfully on favorable spots, not exactly on the coast, but a mile or so inland. And when the time comes a man can make his living by farming on a small scale. I have grown barley suitable for home use for the last five years without failure, and I have by no means the best ground around here, nor am I giving it extraordinary cultivation.

G. W. Palmer, Knik, Cook Inlet, Alaska.—The seed you sent me last fall were received and planted in the spring of 1904. I gave the natives all that I did not use myself. The summer has been very cold and wet, and very unsatisfactory for gardening. Potatoes have done fairly well. I had about 2 tons on about half an acre of ground. Turnips, ruta-bagas, and carrots did fairly well; cabbage did not head firm and hard as they did last year. Lettuce was fine. Beets, parsnips, radishes, and onions were failures.

The natives' gardens were almost a failure from lack of attention.

Herman Stetler, Lower Kenai Lake, via Seward, Alaska.—In the fall of 1902 I obtained from Mr. Nielsen, in charge of Kenai Station, some Department seeds which were planted in 1903, with the following results:

My gardens were planted on the banks of the Kenai River about 2 miles above the Lower Lake, where they were sheltered from the cold winds from all sides and the open river gives a southern exposure. The soil is alluvial, overlying a gravel deposit to a depth of 16 to 24 inches, well drained and loamy.

The first year, 1903, no manure was used, but this year a compost of fish, grass, leaves, etc., was prepared which added materially in the growth of the vegetables. In 1903 only a small area, perhaps 50 feet square, was planted. The result being so encouraging I was induced to experiment further this season. The first year there was more sunshine and the beets and parsnips did better than they did this season, and the peas (Alaska and Earliest of All) ripened, but the seed when planted did not produce well, half of them not coming up at all and the others very late. The few potatoes I grew I saved for seed and they did much better than those from the States.

This year I planted my potatoes May 5 on manured ground. The other seeds—turnip, beets, carrots, kale, cabbage, lettuce, and radishes—were planted between that date and May 15, before the ground was thoroughly thawed out, on fertilized soil. Such care was given them as a lone prospector could find time for and the results were entirely satisfactory.

From less than one-fourth of an acre I grew 3 sacks of potatoes besides what was used, 5 sacks of ruta-bagas, 8 sacks of White Egg turnips, 1 bushel of carrots, and 100 heads of cabbage. Beets and parsnips were very poor, not over one-half bushel together. Besides this we had plenty of kale, lettuce, radishes, and some peas, the latter did not do well. On enriched land the tendency was for the peas and potatoes to go to vines.

The season was exceptionally cold and rainy, not at all favorable to vegetable growth, but the following sizes of some turnips will demonstrate the possibilities of our section in the garden line. One Purple Top turnip 29¼ inches in circumference, 3½ inches thick; 12 or more White Egg turnips were 13 inches long, 20 to 23 inches around; cabbage which weighed 5 or 6 pounds; ruta-bagas weighing 4 to 5 pounds. Cabbage and ruta-bagas were transplanted. Kale grew very thrifty, as did the lettuce and radishes.

Mrs. J. M. Stewart, Valdez, Alaska.—I wish to tell you how successful I was during the season of 1904 with the garden planted with seed you sent me in the spring.

I had lettuce and radishes on June 2, beautifully crisp and tender. We thought the curled lettuce a nicer variety than the Big Boston, which we planted this year. We found the French Breakfast radishes matured more quickly and were more tender than a longer variety of which I forget the name. We raised five different crops of radishes.

I was more successful with onion sets than with seed, as I left the seed till it was too late for planting.

I had 30 beautiful heads of cauliflower from plants started March 20 in the house and transplanted May 15. I had turnips, large ruta-bagas, and beets, which were not very large but very sweet and good. We had plenty of kale and rhubarb, which I had started the year before.

Then I had lots of flowers. I found sweet alyssum and pansies the most satisfactory, as they blossom early and are not injured easily by the frost. I picked the last bunch of flowers October 28. There were, besides candytuft, mignonette, cornflower, asters, and some English daisies started in the house, of which I was especially proud.

I felt much encouraged with my garden, for the season though early was very rainy and cold.

W. H. Marrett, Haines, Alaska.—Wheat, oats, barley, and buckwheat just barely matured during the last season (1904), which has been the coldest I have known in Alaska. Of such vegetables as potatoes, turnips of numerous varieties, cabbage, cauliflower, carrots, beets, parsnips, radishes, lettuce, celery, and peas I have raised an abundance for table use, and several tons surplus of potatoes, turnips, carrots, and cabbage, but in no case was the yield per acre at all remarkable. This year and also last the first frost was not until October. I plowed last season 12 acres in December, finishing the 12th of the month. Most years I could plow nearly or quite as late. Spring plowing is always best, however, on my farm, as the fall of snow prevents much freezing, so that the root crops if left in the ground come out in the spring uninjured by the cold.

Hay has been my only large crop. I have harvested and thoroughly cured this past season a little over 60 tons. Every year there has been some excellent weather for making hay, but it can not be counted on at any particular time. During 1903 there was several weeks of clear sunshine and no rain. The previous year there was not two successive days during July and August without some rain, but that year the really good hay weather was in June.

This year it was late in August and September. I have a silo, but prefer putting my entire crop of grass into hay when I can hit suitable weather for making it.

My attention has been called several times to the fact that the cultivated grasses, such as timothy and clover, have winterkilled badly in some sections. Has not this been chiefly on account of insufficient drainage? All along those many miles of trail the pack train traversed during the Yukon rush the volunteer clover and timothy grow most luxuriantly and does not appear to winterkill in the least. The large parade ground at the military post which was sowed last July with varieties and proportions of seed recommended by you wintered perfectly and is looking remarkably well, though it has been much used, and for several months the horses and cattle were not kept off.

Henry Partridge, Hoonah, Alaska.—I received from the Department beet, carrot, pea, turnip, parsnip, ruta-baga, lettuce, and onion seeds. They all grew very well. With 600 turnip plants I raised 1,800 pounds of nice, juicy turnips; 650 ruta-baga plants weighed 1,920 pounds—the finest ruta-bagas I ever tasted; 250 carrot plants yielded 118 pounds; some carrots were 12 inches long and 9 inches in circumference; 80 parsnip plants yielded 50 pounds; 100 onion plants yielded 18 pounds, the largest being about 2 inches in diameter; 100 beets weighed 70 pounds, and were of the best quality one could wish to see. Peas and lettuce grew fine.

I also planted 50 pounds of potatoes which I took from a sack which we had bought to eat. To my great surprise the 50 pounds grew to 490 pounds of the best and mealiest potatoes I ever ate.

This little garden is located about 20 miles from Hoonah village, near Swanson Harbor. It is 80 by 100 feet. The soil is a deep black loam. To fertilize the ground I used decayed seaweed and old salmon from the streams. I expect too add a little to the patch every year until it is a modern farm. I am satisfied that farming can be made a success in Alaska.

Charles B. Bohm, Tree Point Light Station, Alaska.—This year's (1904) crop has not been exceedingly good on account of using new ground and no fertilizer. I have been trying to catch fish for use as fertilizer with a view to improving the soil.

I have a few onions, some lettuce, some Extra Early Paris cauliflower, and some potatoes, but they all grew very slowly. I also have a little Early Curled parsley and a few heads of cabbage. The Crimson Globe beets grew up a few inches and then stopped. Champion ruta-bagas and Tall Curled Scotch kale are growing fine.

Flowers have done well. The wallflower is 3 feet high, but without blossoms. The poppies are 3½ feet and full of blossoms.

G. W. Gervais, Hollis, Alaska.—In regard to the growth of seed planted in 1904, I will say that it was a very backward year, and nothing did as well this year as last. The Early Jersey Wakefield cabbage and the cauliflower were fairly good; also the Early turnip and Long Red radishes and the Mammoth Red Leaf lettuce. Onions from sets did well. Rhubarb is a great success. I shall try again in 1905.

Nathan B. Whitfield, Ketchikan, Alaska.—Owing to the backward and cool spring in 1904, gardening did not begin here till the last of May or the first of June. The seed sent me were planted on the same soil which last year produced better results than it did this year with the same amount of attention.

Last year (1903) lettuce grew 14 inches across the head, this year from 10 to 12 inches; last year turnips grew to 5 inches in diameter, this year 4 inches; last year beets grew to 3½ inches in diameter, this year 2½ inches; last year carrots reached 1½ inches in diameter, this year 1 inch; last year radishes grew to 1½ inches in diameter, this year 1 inch; last year onions were 2 inches in diameter, this year 1 inch; last year cabbages headed, this year they did not; the beans bloomed last year, this year they did not, being a very tender plant; this climate is too cold for them to mature. Kale grew well, bloomed, but the seeds would not ripen. Peas grew 5½ feet high, and were loaded with fruit, which did not ripen.

The flowers did not do well. They all came up, but only the sweet peas bloomed. I have three plants of sunflower 2 feet high, which are protected. One has a bud, but I do not think it will bloom.

From information derived from the natives and old white settlers this has been an unusually wet and cold year, and is not a good criterion of the productive qualities of Alaska horticulturally.

SOIL TEMPERATURES.

Readings are taken at 7 a. m. Thermometers record the temperature at depths of 6 and 24 inches, respectively. The radiation thermometer shows the daily minimum temperature 6 inches above the surface of the ground where the soil thermometers are planted.

Soil temperatures.

SITKA EXPERIMENT STATION.

Date.	Temperature.			Date.	Temperature.			Date.	Temperature.		
	At 7 a. m. 6 inches below surface.	At 7 a. m. 24 inches below surface.	Minimum at 6 inches above surface.		At 7 a. m. 6 inches below surface.	At 7 a. m. 24 inches below surface.	Minimum at 6 inches above surface.		At 7 a. m. 6 inches below surface.	At 7 a. m. 24 inches below surface.	Minimum at 6 inches above surface.
1905.	° F.	° F.	° F.	1905.	° F.	° F.	° F.	1905.	° F.	° F.	° F.
May 8	45	42.5	38	June 13	49	48	38	July 19	56.5	52	49
May 9	44	42.5	37	June 14	50.5	48	37	July 20	58.5	52	50
May 10	46	42.5	38	June 15	51.5	48	45	July 21	58.5	52	52
May 11	45.5	43	37	June 16	51	48	46	July 22	58.5	52.5	54
May 12	46	43	41	June 17	52	48	47	July 23	58	52.5	50
May 13	45	43.5	35	June 18	51	48	45	July 24	57.5	52.5	44
May 14	45	43.5	31	June 19	51.5	48.5	44	July 25	57	53	43
May 15	45	43.5	34	June 20	52	48.5	47	July 26	57	53	44
May 16	44	43.5	40	June 21	52.5	48.5	47	July 27	58	53	48
May 17	44	43.5	36	June 22	53.5	48.5	42	July 28	57	53	52
May 18	45.5	43.5	39	June 23	53	49	49	July 29	57	53	52
May 19	45.5	43.5	41	June 24	56	49	47	July 30	57	52	52
May 20	45.5	44	39	June 25	58	49.5	50	July 31	57	53	44
May 21	46.5	44	30	June 26	57	49.5	42	Aug. 1	58	53.5	46
May 22	47	44	31	June 27	56	50	50	Aug. 2	58	53.5	52
May 23	47.5	44	36	June 28	55	50	47	Aug. 3	58.5	53.5	51
May 24	48	44	37	June 29	54.5	50.5	48	Aug. 4	57	53.5	52
May 25	48	45.5	35	June 30	54.5	50.5	48	Aug. 5	57	53.5	42
May 26	48.5	45	35	July 1	55.5	50.5	51	Aug. 6	58	53.5	48
May 27	50	45	35	July 2	55	50.5	48	Aug. 7	58	53.5	52
May 28	50.5	45	41	July 3	54.5	50.5	49	Aug. 8	57.5	54	51
May 29	50	45.5	36	July 4	54	51	50	Aug. 9	57.5	54	51
May 30	50	46	36	July 5	54	51	47	Aug. 10	57.5	54	49
May 31	50	46	36	July 6	52	51	44	Aug. 11	57	54	52
June 1	50.5	46	36	July 7	53	51	47	Aug. 12	57	54	51
June 2	50.5	46	37	July 8	53	51	47	Aug. 13	57	54	41
June 3	50.5	46.5	35	July 9	54	51	47	Aug. 14	57	54	42
June 4	50.5	46.5	40	July 10	55	51	49	Aug. 15	56	54	42
June 5	50.5	47	34	July 11	55	51	46	Aug. 16	56	54	45
June 6	51.5	47	40	July 12	55	51	47	Aug. 17	56	54	47
June 7	52	47	40	July 13	54.5	51	48	Aug. 18	56	54	44
June 8	52	47.5	47	July 14	55	51	49	Aug. 19	55.5	54	45
June 9	51.5	47.5	46	July 15	55	51	52	Aug. 20	55	54	44
June 10	50.5	47.5	37	July 16	53.5	51	50	Aug. 21	55	54	46
June 11	50.5	48	37	July 17	56	51.5	50	Aug. 22	54	54	46
June 12	49.5	48	41	July 18	55.5	52	50	Aug. 23	54	53.5	46

Soil temperatures—Continued.

SITKA EXPERIMENT STATION—Continued.

Date.	Temperature.			Date.	Temperature.			Date.	Temperature.		
	At 7 a. m. 6 inches below surface.	At 7 a. m. 24 inches below surface.	Minimum at 6 inches above surface.		At 7 a. m. 6 inches below surface.	At 7 a. m. 24 inches below surface.	Minimum at 6 inches above surface.		At 7 a. m. 6 inches below surface.	At 7 a. m. 24 inches below surface.	Minimum at 6 inches above surface.
1905.	° *F.*	° *F.*	° *F.*	1905.	° *F.*	° *F.*	° *F.*	1905.	° *F.*	° *F.*	° *F.*
Aug. 24	54	53.5	46	Sept. 12	53.5	52	49	Oct. 1	46	49.5	42
Aug. 25	56	53.5	46	Sept. 13	53.5	52	44	Oct. 2	45.5	49	41
Aug. 26	55	53.5	49	Sept. 14	53	52	41	Oct. 3	44	49	43
Aug. 27	54.5	53.5	43	Sept. 15	53	52	48	Oct. 4	46	49	40
Aug. 28	54	53.5	38	Sept. 16	52.5	52	48	Oct. 5	46.5	48.5	41
Aug. 29	53	53.5	35	Sept. 17	50.5	52	40	Oct. 6	46.5	48.5	38
Aug. 30	53	53.5	36	Sept. 18	50.5	52	39	Oct. 7	46.5	48.5	38
Aug. 31	53	53	50	Sept. 19	51	52	46	Oct. 8	46.5	48.5	35
Sept. 1	53	53	49	Sept. 20	51	52	44	Oct. 9	45	48	39
Sept. 2	53	53	46	Sept. 21	50	51.5	39	Oct. 10	46	48	48
Sept. 3	53	53	44	Sept. 22	48	51	39	Oct. 11	47.5	48	42
Sept. 4	53	53	44	Sept. 23	47.5	51	32	Oct. 12	47	48	40
Sept. 5	53	53	39	Sept. 24	48	51	40	Oct. 13	48	48	41
Sept. 6	53	53	35	Sept. 25	48.5	50.5	45	Oct. 14	48	48	33
Sept. 7	52.5	53	38	Sept. 26	48	50	35	Oct. 15	43	48	27
Sept. 8	52	52.5	35	Sept. 27	48	50	38	Oct. 16	43	48	24
Sept. 9	52	52	49	Sept. 28	48	50	40	Oct. 17	42.5	47	29
Sept. 10	53	52	41	Sept. 29	47	49.5	40	Oct. 18	40	47	32
Sept. 11	53	52	45	Sept. 30	46	49.5					

COPPER RIVER EXPERIMENT STATION.

May 10	38.5	32		June 27	59	48.5	38	Aug. 14	49	46.5	7
May 11	41	32	24	June 28	57.5	48.5	30	Aug. 15	53	46.5	26
May 12	43	32	21	June 29	55.5	48.5	38	Aug. 16	52	46.5	32
May 13	37.5	32	14	June 30	53	48.5	35	Aug. 17	53	46.5	31
May 14	36	32	6	July 1	55	48	33	Aug. 18	52.5	46.5	19
May 15	39	32	15	July 2	56.5	48	38	Aug. 19	51	47	17
May 16	40.5	32	14	July 3	57.5	48	37	Aug. 20	54	47	24
May 17	39	32	9	July 4	56	48	36	Aug. 21	49	47	9
May 18	41	32	21	July 5	51	48	33	Aug. 22	50	46.5	8
May 19	38	32	8	July 6	52.5	47.5	39	Aug. 23	49	46	3
May 20	40	32.5	10	July 7	52	47	32	Aug. 24	49.5	46	5
May 21	43.5	32.5	31	July 8	50	47	30	Aug. 25	49	46	30
May 22	43	32.5	19	July 9	51.5	46.5	22	Aug. 26	44.5	45.5	10
May 23	42	33	31	July 10	55.5	46	23	Aug. 27	43	45	8
May 24	44	33	28	July 11	56	46.5	37	Aug. 28	44	43.5	0
May 25	45	33.5	34	July 12	54.5	47.5	33	Aug. 29	47	43.5	24
May 26	44.5	33.5	31	July 13	52.5	47.5	35	Aug. 30	43.5	43.5	29
May 27	45.5	33.5	35	July 14	54.5	47.5	21	Aug. 31	47.5	43.5	24
May 28	43.5	34	15	July 15	56	47.5	37	Sept. 1	44	43.5	6
May 29	44.5	34	18	July 16	53	47.5	33	Sept. 2	43.5	43.5	5
May 30	43.5	34.5	14	July 17	54	47.5	30	Sept. 3	47	43.5	20
May 31	45.5	35	30	July 18	52	47.5	17	Sept. 4	44	43.5	10
June 1	46	35.5	25	July 19	55	47.5	18	Sept. 5	43.5	43.5	22
June 2	48	36	24	July 20	58	48	21	Sept. 6	43	45.5	4
June 3	47.5	37	24	July 21	58.5	48.5	40	Sept. 7	43	43.5	9
June 4	45	37	13	July 22	55	48.5	21	Sept. 8	44	43.5	16
June 5	47.5	37	26	July 23	58.5	49	22	Sept. 9	44.5	45.5	20
June 6	50	37.5	30	July 24	60.5	49.5	37	Sept. 10	43	43.5	9
June 7	47.5	38	18	July 25	60.5	50	26	Sept. 11	43.5	44	23
June 8	50	38.5	32	July 26	61	50.5	24	Sept. 12	43.5	42	14
June 9	48	38.5	18	July 27	62.5	51	34	Sept. 13	43.5	43	16
June 10	48.5	39	20	July 28	62	51	27	Sept. 14	43	43	20
June 11	47	39.5	12	July 29	56	51	25	Sept. 15	44	43	17
June 12	48	39.5	29	July 30	57	51.5	21	Sept. 16	43	43	18
June 13	45.5	39.5	29	July 31	59	51.5	24	Sept. 17	44	43	14
June 14	47	39.5	28	Aug. 1	57	51	31	Sept. 18	40.5	42.5	15
June 15	48.5	40	26	Aug. 2	56	51	32	Sept. 19	39	42.5	6
June 16	50	40.5	19	Aug. 3	56	50	34	Sept. 20	38	42	13
June 17	48	41	32	Aug. 4	55	49.5	27	Sept. 21	38	41	14
June 18	46.5	41	22	Aug. 5	54	49	34	Sept. 22	38	40.5	13
June 19	50.5	41	35	Aug. 6	53	48.5	30	Sept. 23	38	40.5	5
June 20	51	41.5	21	Aug. 7	54	48.5	24	Sept. 24	34.5	39.5	−5
June 21	51.5	42	18	Aug. 8	55	48.5	33	Sept. 25	33	39	−5
June 22	57	43	39	Aug. 9	54	48.5	34	Sept. 26	33.5	38	−3
June 23	58	44.5	38	Aug. 10	53	48	36	Sept. 27	33	37.5	2
June 24	58.5	45.5	28	Aug. 11	53	47.5	30	Sept. 28	33	37	−3
June 25	60.5	47	31	Aug. 12	50.5	47.5	23	Sept. 29	33.5	37	−1
June 26	59	48	36	Aug. 13	49.5	47	15	Sept. 30	32.5	36.5	−4

Soil temperatures—Continued.

KENAI EXPERIMENT STATION.

Date.	Temperature.		Date.	Temperature.		Date.	Temperature.	
	At 7 a. m. 6-inch thermometer.	At 7 a. m. 24-inch thermometer.		At 7 a. m. 6-inch thermometer.	At 7 a. m. 24-inch thermometer.		At 7 a. m. 6-inch thermometer.	At 7 a. m. 24-inch thermometer.
1905.	°*F.*	°*F.*	1905.	°*F.*	°*F.*	1905.	°*F.*	°*F.*
May 4	35.5	....	June 13	46.5	38	Aug. 23	51.5	50
May 5	33.5	....	June 14	46.5	38.5	Aug. 24	52.5	50
May 6	33.5	....	June 15	48.5	38.5	Aug. 25	53	50
May 7	34	....	June 16	46.5	39	Aug. 26	50.5	50
May 8	34	....	June 17	46	39.5	Aug. 27	48.5	50
May 9	34	....	June 18	46	39.5	Aug. 28	49	49.5
May 10	35	....	June 19	47	39.5	Aug. 29	51	49.5
May 11	35.5	....	June 20	48.5	40	Aug. 30	51	49
May 12	35	....	June 21	48	40	Aug. 31	49.5	49
May 13	35	....	June 22	48.5	40.5	Sept. 1	51.5	49
May 14	36	....	June 23	47.5	40.5	Sept. 2	51	49
May 15	36	....	June 24	49.5	41	Sept. 3	47.5	49
May 16	37.5	....	June 25	52	41	Sept. 4	48	49
May 17	38.5	....	June 26	51.5	42	Sept. 5	47.5	48.5
May 18	37.5	....	June 27	52.5	42	Sept. 6	47.5	48.5
May 19	41.5	....	June 28	53	42.5	Sept. 7	48.5	48
May 20	39	....	June 29	52	43	Sept. 8	49	48
May 21	39.5	....	June 30	51.5	43	Sept. 9	49	48
May 22	39	....	Aug. 1	57	50	Sept. 10	50	48
May 23	40.5	....	Aug. 2	55.5	50	Sept. 11	48.5	47.5
May 24	40.5	....	Aug. 3	55	50.5	Sept. 12	45	47.5
May 25	40	....	Aug. 4	55	50.5	Sept. 13	46.5	47
May 26	42	....	Aug. 5	55	50.5	Sept. 14	48.5	46.5
May 27	42	....	Aug. 6	57	50.5	Sept. 15	48	46.5
May 28	40.5	....	Aug. 7	55.5	50.5	Sept. 16	48	46.5
May 29	42	....	Aug. 8	56	50.5	Sept. 17	45	46.5
May 30	42	....	Aug. 9	54.5	50.5	Sept. 18	45	46
May 31	43	....	Aug. 10	53	50.5	Sept. 19	43.5	45.5
June 1	44	35	Aug. 11	52.5	50.5	Sept. 20	43.5	45.5
June 2	41.5	35	Aug. 12	53	50	Sept. 21	42.5	45
June 3	44.5	35.5	Aug. 13	52.5	50	Sept. 22	42.5	44.5
June 4	44	35.5	Aug. 14	53	50	Sept. 23	40	44
June 5	46	36	Aug. 15	52.5	50	Sept. 24	39	43.5
June 6	45	36.5	Aug. 16	53	50	Sept. 25	37.5	43
June 7	45	37	Aug. 17	51.5	50	Sept. 26	37	42.5
June 8	44.5	37	Aug. 18	54	50	Sept. 27	36.5	42
June 9	47.5	37.5	Aug. 19	54	50	Sept. 28	36.5	41.5
June 10	43.5	37.5	Aug. 20	53	50	Sept. 29	35.5	41.5
June 11	43.5	37.5	Aug. 21	52.2	50	Sept. 30	35	41
June 12	44	38	Aug. 22	53	50			

METEOROLOGICAL REPORTS.

As in former years, the special agent has had general supervision of the voluntary weather observers of the Weather Bureau of Alaska. In the following tables are given condensed reports taken from the daily records of the different observers:

Meteorological observations.

SITKA. C. C. Georgeson, observer.

Month.	Temperature.			Total precipitation.	Weather conditions (number of days).			
	Maximum.	Minimum.	Daily mean.		Clear.	Partly cloudy.	Cloudy.	Rain or snow.
	° F.	*° F.*	*° F.*	*Inches.*				
1904.								
October	59	33	46.39	10.38	4	11	15	25
November	59	30	40.20	8.68	1	6	23	24
December	51	24	38.95	8.08	0	5	26	25
1905.								
January	55	22	36.40	3.12	7	8	16	9
February	53	20	37.12	4.78	5	6	17	13
March	65	31	43.93	4.21	7	7	17	22
April	57	25	42.80	7.52	10	4	16	20
May	65	32	47.11	2.44	11	12	8	16
June	84	40	52.80	2.25	8	7	15	13
July	73	44	56.38	2.83	15	5	11	14
August	69	45	56.12	7.38	8	5	18	16
September	64	35	50.70	8.80	6	17	7	7

KENAI. P. H. Ross, observer.

Month.	Maximum.	Minimum.	Daily mean.	Total precipitation.	Clear.	Partly cloudy.	Cloudy.	Rain or snow.
1904.								
October	56	9	35.92	1.71	10	2	19	24
November	39	21	17.08	.26	10	7	13	5
December	39	20	14.99	.66	13	5	13	11
1905.								
January	39	-14	16.07	.29	20	5	6	5
February	48	7	31.22	.92	1	4	23	8
March	59	10	34.17	.57	8	9	14	4
April	68	8	38.64	.46	5	16	9	5
May	63	22	44.22	.84	12	13	6	11
June	69	28	31.59	.84	16	7	7	10
July	81	36	55.75	1.06	13	6	12	10
August	78	27	54.94	6.25	12	7	12	19
September	72	13	43.64	.78	15	7	8	6

COPPER CENTER. J. W. Neal, observer.

Month.	Maximum.	Minimum.	Daily mean.	Total precipitation.	Clear.	Partly cloudy.	Cloudy.	Rain or snow.
1904.								
October	55	0	30.51	0.48	15	8	8	6
November	34	-29	-3.33	.36	14	6	10	9
December	32	-31	-4.69	.68	3	15	13	6
1905.								
January	39	-44	-7.93	.29	16	4	10	4
February	44	-32	9.81	1.01	14	10	4	2
March	47	1	21.82	2.00	22	2	7	1
April	56	6	31.46	.00	13	8	9	0
May	69	20	44.32	.48	3	16	12	7
June	88	27	55.95	.50	4	18	8	5
July	88	33	59.19	1.35	7	12	10	7
August	74	20	52.22	.72	6	10	15	8
September	67	12	38.86	1.94	9	4	16	10

RAMPART. Fred E. Rader, observer.

Month.	Maximum.	Minimum.	Daily mean.	Total precipitation.	Clear.	Partly cloudy.	Cloudy.	Rain or snow.
1905.								
June[a]	80	31	54.7	1.33	2	8	......	......
July	86	32	55.7	1.99	8	8	15	13
August	96	26	54.5	2.19	9	10	12	13
September	60	13	35.10	1.70	3	5	22	11

[a] Ten days

Meteorological observations—Continued.

LORING (FORTMANN SALMON HATCHERY). Fred Patching, observer.

Month.	Temperature.			Total precipitation.	Weather conditions (number of days).			
	Maximum.	Minimum.	Daily mean		Clear.	Partly cloudy.	Cloudy	Rain or snow.
1904.	°F.	°F.	°F.	*Inches.*				
July	76	36	53.36	7.79	5	9	17	23
August	82	41	58.48	1.15	13	4	14	8
September	72	34	50.5	20.20	5	1	24	22
October	67	28	45.74	26.01	5	3	23	23
November	58	30	41	32.10	....	6	24	30
December	54	15	38.36	20.01	....	6	25	27
1905.								
January	41	7	25.5	5.18	5	9	17	13
February	48	9	32.1	13.27	....	6	22	15
March	63	26	40	16.53	....	4	27	23
April	66	21	42.4	11.65	7	16	7	21
May	93	29	50	9.46	15	4	12	15
June	91	41	58.6	.84	14	3	13	4
July	87	42	60.2	5.26	18	2	11	14
August	85	39	57.93	13.43	3	5	23	23
September	70	35	50.5	13.85	3	10	17	21
October	55	23	43.65	17.94	3	9	19	23

PETERSBURG. J. A. Goding, observer.

Month.	Maximum.	Minimum.	Daily mean	Total precipitation.	Clear.	Partly cloudy.	Cloudy	Rain or snow.
1904.								
October	69	31	45.15	13.89	6	....	25	6
November	61	25	31.04	13.52	4	11	15	4
1905.								
April	62	21	42.36	7.17	14	4	12	16
May	72	28	49.91	3.03	15	8	8	12
June	80	39	55.73	1.95	11	3	16	9
July	76	39	56.67	4.46	14	3	14	10
August	80	35	26.7	10.76	6	5	20	4

JUNEAU. S. J Sharick, observer.

Month.	Maximum.	Minimum.	Daily mean	Total precipitation.	Clear.	Partly cloudy.	Cloudy	Rain or snow.
1904.								
October	63	29	48.54	10.14	12	....	19	22
November	53	22	38.93	8.79	12	....	18	28
December	52	17	38.56	9.88	11	....	20	23
1905.								
January	47	14	32.76	3.28	25	....	6	7
February	51	14	34.14	2.85	23	....	5	9
March	56	30	41.06	8.40	18	....	12	18
April	66	30	40.93	6.76	14	....	16	15
May	74	33	49.31	3.83	27	....	4	12
June	84	41	57.06	3.68	21	....	9	12
July	83	49	59.91	1.93	23	....	8	11
August	73	38	27.39	8.83	14	....	17	18
September	68	35	50.44	6.11	12	....	18	25
October	56	27	43.66	12.74	11	....	20	15

SKAGWAY. H. D. Clark, observer.

Month.	Maximum.	Minimum.	Daily mean	Total precipitation.	Clear.	Partly cloudy.	Cloudy	Rain or snow.
1904.								
October	61	24	43.3	5.35	6	15	10	16
November	44	20	32.5	3.73	1	16	13	13
1905.								
January	39	2	24.5	....	15	7	9	....
February	49	9	28.5	1.14	9	8	11	2
March	54	26	38	1.14	7	14	10	9
April	58	25	41.5	1.27	10	17	3	3
May	75	25	50	1.11	16	10	5	3
June	84	36	57.7	.10	10	11	9	1
July	83	43	59.3	.16	18	6	7	5
August	75	32	55.5	2.14	5	16	10	6
September	64	32	48.6	2.67	4	15	11	15
October	55	26	41.06	2.17	6	10	15	5

Meteorological observations—Continued.

KILLISNOO. Joseph Zuboff, observer.

Month.	Temperature.			Total precipitation.	Weather conditions (number of days).			
	Maximum.	Minimum.	Daily mean.		Clear.	Partly cloudy.	Cloudy.	Rain or snow.
1904.	° *F.*	° *F.*	° *F.*	*Inches.*				
October	57	29	41.8	0.20	7	21	4	20
November	52	28	37.6	9.20	2	26	2	24
December	53	16	36.2	8.55	2	23	6	23
1905.								
January	43	12	29.10	1.90	9	17	5	9
February	50	14	32.6	2.80	1	25	2	16
March	53	26	39.49	2.60	4	13	14	16
April	61	24	41.2	2.20	7	14	9	9
May	64	31	47.7	3	16	7	8	8
June	83	40	53.2	1.20	10	9	11	6
July	71	41	55	1.60	9	12	10	5
August	74	36	54.05	4.30	4	10	17	14
September	62	35	48.4	4.75	3	4	23	16
October	55	26	42.62	4.10	6	5	20	16

ORCA. W. J. Shephard, observer.

1904.								
October	53	30	40.38	27.57	6	--------	25	25
November	46	15	32.51	9.66	6	11	13	14
December	47	21	32.53	19.05	5	11	15	17
1905.								
January	45	21	31.17	8.20	12	8	11	11
February	45	22	33.94	11.55	6	9	13	11
March	61	22	38.86	12.51	9	4	18	18
April	70	27	41.69	8.60	12	2	16	14
May	72	30	45.91	10.41	8	11	12	16
June	83	37	53.6	6.51	11	11	8	12
July	84	43	58.9	5.02	10	18	3	7
August	80	40	56.30	14.59	12	4	15	17
September	79	30	71.06	9.54	15	8	7	13
October	64	31	42.46	6.54	9	13	9	18

FORT LISCUM. C. J. Steadman, observer.

1904.								
October	53	13	35.5	9.35	10	2	19	21
November	40	11	18.3	2.21	9	5	16	13
December	42	9	19	8.31	5	5	21	22
1905.								
January	44	7	13.44	2.12	18	2	11	8
February	45	9	29.07	1.93	7	4	17	12
March	58	11	32.07	1.64	10	8	13	9
April	57	10	36.23	3.41	12	7	11	12
May	63	27	43.51	.84	9	8	14	15
June	76	31	51.7	.69	11	12	7	11
July	75	38	56.6	1.40	6	15	10	14
August	70	31	53.34	4.52	9	2	20	20
September	65	20	42.2	1.86	14	4	12	11

TYONEK. Durell Finch, observer.

1905								
June	67	37	52.06	1.27	16	--------	14	6
July	80	42	58.47	.92	16	3	12	5
August	75	40	57.27	4.75	15	2	14	9
September	79	22	47.63	.92	17	5	8	3

Meteorological observations—Continued.

Month.	Temperature. Maximum.	Temperature. Minimum.	Temperature. Daily mean.	Total precipitation.	Weather conditions (number of days). Clear.	Partly cloudy.	Cloudy.	Rain or snow.
WOOD ISLAND. S. A. Coldwell, observer.								
1904.	° *F.*	° *F.*	° *F.*	*Inches.*				
October	57	24	42.27	4.84	12	--------	19	11
November	52	12	34.7	5.20	7	--------	23	11
December	55	10	32.74	3.64	10	--------	21	11
1905.								
January	53	20	33.33	4.80	10	--------	21	7
February	50	28	38.8	3.90	4	--------	24	12
March	65	30	40.42	2.60	10	--------	21	7
June	74	42	54.29	3.10	8	--------	22	11
July	74	32	36.72	2.10	11	--------	20	3
August[a]	74	31	53.88	----------	7	--------	14	--------
September	55	32	43.95	1.80	5	4	21	2
SUNRISE. A. Lawson, observer.								
1904.								
October	53	13	35.5	9.35	10	2	19	21
November	40	−11	18.3	2.21	9	5	16	13
December	42	−9	19	8.31	5	5	21	22
1905.								
January	44	−7	13.44	2.12	18	2	11	8
February	45	9	29.07	1.93	7	4	17	12
March	58	11	32.07	1.64	10	8	13	9
April	57	10	36.23	3.41	12	7	11	12
May	63	27	43.51	.84	9	8	14	15
June	76	31	51.7	.69	11	12	7	11
July	75	38	56.6	1.40	6	15	10	14
August	70	31	53.34	4.52	9	2	20	20
September	65	20	42.2	1.86	14	4	12	11
COAL HARBOR, UNGA ISLAND. Henry S. Tibbey, observer.								
1904.								
September	64	33	48.33	3.73	10	8	12	9
October	57	23	39.61	3.08	7	10	14	18
November	43	17	31.91	2.51	11	7	12	6
December	39	4	25.4	2	10	13	8	14
1905.								
January	42	4	31.3	.17	8	14	9	5
February	42	11	33.11	9.03	6	9	13	19
March	49	11	32.7	1.20	10	16	5	6
April	56	19	38.7	18.92	5	14	11	27
May	56	29	42.7	6.76	1	18	12	23
June	69	37	48.8	4.44	4	8	18	20
July	74	40	55.1	1.75	10	8	13	6
August	70	40	55.6	2.20	13	11	7	9
September	66	35	48.8	2.95	12	9	9	11
DUTCH HARBOR. F. Schroder, observer.								
1905.								
May[b]	55	30	42.8	3.66	4	6	10	10
June	62	37	47	4.69	3	12	15	14
July	69	49	52.26	1.73	2	15	14	8
August	68	42	52.78	3.39	3	5	23	12
September	61	33	46.1	3.46	5	8	17	14

[a] Twenty-one days.

[b] Twenty days.

Meteorological observations—Continued.

NUSHAGAK. J. Kahlen, observer.

Month.	Temperature.			Total precipitation.	Weather conditions (number of days).			
	Maximum.	Minimum.	Daily mean.		Clear.	Partly cloudy.	Cloudy.	Rain or snow.
1904.	° *F.*	° *F.*	° *F.*	*Inches.*				
August	67	37	51.39	4.52	5	2	24	18
September	73	24	46.84	4.16	14	1	15	9
October	54	3	33.22	1.66	13	6	12	11
November	37	−15	15.4	----------	15	4	11	--------
December	42	−54	10.5	.56	15	1	15	4
1905.								
January	38	−15	16.9	.20	18	3	10	2
February	44	− 7	25	1.45	7	1	20	4
March	47	−18	23	.40	16	4	11	1
April	52	7	32.8	.40	12	3	15	1
May	61	--------	41	2.51	10	4	17	12
June	71	18	22.93	2.75	10	3	17	14
July	78	36	56.77	3.84	14	2	15	11

KOTZEBUE. Dana Thomas, observer.

1904.								
May	55	9	30.5	----------	--------	--------	--------	--------
June	--------	--------	--------	----------	--------	--------	--------	--------
July	70	40	55.8	----------	--------	--------	--------	--------
August	--------	--------	--------	----------	--------	--------	--------	--------
September	65	24	41.16	----------	--------	--------	--------	--------
October	57	5	27.70	----------	--------	--------	--------	--------
November	22	−25	8.16	----------	--------	--------	--------	--------

TEIKHELL. J. H. Embleton, observer.

1904.								
October	50	9	31	2.82	9	--------	22	14
November	40	−23	4.51	.90	14	--------	16	10
December	35	−22	2.34	2.94	20	--------	11	8
1905.								
January	34	−26	.27	.98	18	1	12	2
February	42	−21	.11	.49	15	--------	13	2
March	50	− 5	23.46	1.31	15	4	12	2
April	51	1	30.59	----------	--------	--------	--------	--------
May	68	20	43.05	----------	20	3	8	--------
June	70	34	53	.80	18	6	6	1
July	80	32	57	1.05	21	3	7	4
August	75	24	51	.72	9	3	18	8
September	66	15	38.5	1.01	9	1	20	11

CHESTOCHENA. John A. Gustofoson, observer.

1904.								
October	47	4	28.20	----------	9	10	12	--------
November	35	−26	7.53	----------	19	8	3	--------
December	32	−29	7.82	0.2	21	8	2	1
1905.								
January	45	−33	8.26	.5	23	2	5	1
February	38	− 1	33.40	.25	15	5	7	2
March	50	− 8	22.52	----------	15	11	5	--------
April	55	10	31.89	----------	20	6	4	--------
May	68	20	29.14	.48	3	17	11	3
June	87	31	35.74	.90	14	6	10	11
July	80	37	56.93	3.19	19	2	10	12
August	81	27	52.48	3.20	12	3	15	18
September	59	16	38.41	3.11	10	8	12	12

Meteorological observations—Continued.

KETCHEMSTOCK. Daniel B. McCarthy, observer.

Month.	Temperature.			Total precipitation.	Weather conditions (number of days).			
	Maximum.	Minimum.	Daily mean.		Clear.	Partly cloudy.	Cloudy.	Rain or snow.
1904.	*F.*	*F.*	*F.*	*Inches.*				
August	75	28	53	0.94	12	16	3	4
September	64	0	34.3	.59	....	28	2	2
October	51	−10	22.5	.30	7	21	2	2
November	34	−41	7.5	.03	4	26	....	1
December	25	−41	4.1	.18	3	22	5	3
1905								
January	10	−52	4.1	.9	12	13	6	1
February	34	−44	14.6	.10	6	10	12	1
March	45	0	8.99	.5	11	12	8	1
April	35	0	9.9	4	23	3	4	3
May	67	27	21.01	.2	13	10	8	1
June	86	21	56.4	1.58	14	10	6	3
July	83	31	55.1	.4	12	13	6	3
August	78	17	49.4	1.48	....	22	9	7
September	62	9	33	2.16	....	21	9	9

TANANA CROSSING.

1904.								
October	53	− 8	18.04	....	16	10	5	....
November	....	−37	....	....	20	....	10	....
December [a]	....	−29	....	....	13	1	17	....
1905.								
January	....	−45	....	0.24	21	3	7	3
February	....	−41	....	1.5	8	4	16	1
March	....	−19	....	.10	11	7	13	1
April [a]	....	2	....	....	15	10	3	....
May [b]	....	20	....	.14	14	8	5	....
June [c]	83	30	....	.43	15	12	3	4
July	85	30	57.17	.67	15	10	6	8
August	90	32	64.36	2.95	16	9	6	5
September	78	10	41.50	2.80	15	7	8	5

FORT EGBERT. Herman B. Olson, observer.

1905.								
May	75	25	47.3	0.33	9	11	11	6
June	88	33	55.98	1.95	1	9	20	12
July	91	40	64.16	1.52	1	10	20	13
August	82	29	30.56	2.68	....	20	11	12
September	75	52	47.05	2.43	3	8	19	17

FAIRBANKS. Hudson Stuck, observer.

1904.								
September	62	17	39.4	....	15	3	9	6
October	52	− 7	29.1	....	19	2	10	....
November	28	− 35	− 9.79	....	21	3	6	....
December	23	− 47	−12.08	....	....	....	....	....
1905.								
January	20	− 48	−16.93	....	25	....	6	....
February	32	− 30	− 5.23	....	27	....	1	....
April	60	6	34.6	2	....	....	....	....
May	72	22	47.05	....	13	1	10	....
June [d]	80	34	28.78	....	16	....	7	....
July	80	18	55.6	.30	13	8	10	3
August	82	30	54.8	2.73	16	4	11	13

---

[a] Twenty-eight days.
[b] Twenty-three days.
[c] Twenty-five days.
[d] Twenty-seven days.

Meteorological observations—Continued.

FORT GIBBON (Signal Corps). L. M. Hathaway, observer.

Month.	Temperature.			Total precipitation.	Weather conditions (number of days).			
	Maximum.	Minimum.	Daily mean.		Clear.	Partly cloudy	Cloudy.	Rain or snow.
1904.	° *F.*	° *F.*	° *F.*	*Inches.*				
September	--------	--------	--------	0.35	20	5	5	2
October	--------	--------	--------	.39	16	12	3	2
November	--------	--------	--------	.07	22	5	3	1
December	--------	--------	--------	.06	17	4	10	5
1905.								
January[a]	--------	--------	--------	.04	23	2	6	4
February	35	− 24	44.3	.55	13	6	9	4
May	81	12	48	.84	18	3	10	7
June	78	35	56.05	1.85	16	4	10	15
July	77	32	56.5	5.59	10	4	17	18
August	80	31	52.23	3.23	20	1	10	10

FORT GIBBON (hospital observations). Charles W. Heideman, observer.

Month.	Maximum.	Minimum.	Daily mean.	Total precipitation.	Clear.	Partly cloudy	Cloudy.	Rain or snow.
1905								
January	32	−44	−2	0.37	16	2	13	2
February	38	−22	6	.47	10	5	13	3
March	53	−26	14	----------	26	4	1	--------
April	63	7	33	.32	22	--------	8	3
May	81	12	48	.34	15	2	14	7
June	90	32	57.23	1.50	15	3	12	14
July	83	34	56.2	4.90	8	--------	23	17
August	81	28	52.28	3.02	20	--------	11	10

HOLY CROSS MISSION. B. Constantine, observer.

Month.	Maximum.	Minimum.	Daily mean.	Total precipitation.	Clear.	Partly cloudy	Cloudy.	Rain or snow.
1905.								
May	64	16	41.18	----------	8	4	19	--------
June	68	32	45.50	0.08	7	15	8	2
July	78	35	53.51	4.89	12	3	16	12
August	71	35	51.62	1.66	10	13	8	5
September	58	17	38.43	1.38	13	4	13	5

KENNICUT MINES, COPPER RIVER VALLEY. Stephen Birch, observer.

Month.	Maximum.	Minimum.	Daily mean.	Total precipitation.	Clear.	Partly cloudy	Cloudy.	Rain or snow.
1903.								
September	60	18	40.08	----------	22	--------	3	5
October	48	− .1	26.65	1.65	14	--------	10	7
November	44	− .9	3.63	.9	17	--------	11	2
December	32	−10	10.14	2.6	14	--------	9	8
1904.								
January	37	−32	2.88	1.85	12	--------	15	5
February	26	−22	5.34	.65	20	--------	5	4
March	44	−20	12.46	.7	22	--------	5	4

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[a] Fourteen days.

U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 170.

A. C. TRUE, Director.

REPORT

ON

AGRICULTURAL INVESTIGATIONS IN HAWAII,

1905.

BY

JARED G. SMITH,

Special Agent in Charge, Hawaii Agricultural Experiment Station.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., April 30, 1906.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 170 of this Office, a Report on Agricultural Investigations in Hawaii for 1905, by Jared G. Smith, Special Agent in Charge of the Hawaii Agricultural Experiment Station.

Respectfully,

A. C. True, *Director.*

Hon. James Wilson,
Secretary of Agriculture.

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REPORT ON AGRICULTURAL INVESTIGATIONS IN HAWAII, 1905.

The work of the Hawaii Agricultural Experiment Station has been continued along the same general lines described in previous reports. No changes were made in the staff, the various members of which submit their reports herewith. The special agent has given much of his time to administrative duties, superintending building operations, correspondence, preparing bulletins, etc. In the lines of investigation he has continued to give attention to a number of subjects that did not come in the field of the other members of the staff. The principal of these have been studies on grasses and forage plants, tobacco, cassava, coffee and cane diseases, tan-bark production, etc. The special agent and other members of the staff visited quite a number of localities in the Territory in the pursuit of their investigations, and by this means they have become acquainted with a considerable number of those interested in agriculture in its broad sense. Numerous additions were made to the equipment of the laboratories and library, and it is confidently asserted that the station now possesses the best agricultural library in the islands, it being especially strong along the lines of tropical agriculture, entomology, horticulture, and chemistry.

BUILDING OPERATIONS.

Considerable building was done during the year, and in addition to laborers' quarters there are now houses for the special agent, for the chemist, and for the entomologist. A much needed office and laboratory building has been provided; and as it is practically fireproof, the library and more valuable equipment of the station are safely housed for the first time. The laboratory and office building was provided out of funds appropriated by the Territorial authorities, supplemented by station funds. The building is 35 by 60 feet, with concrete walls, foundation, and floors, and a corrugated-iron roof. The station installed the floors, the foundation, and the larger share of the internal equipment. The inner walls and floors were built without a finishing coat, there being no ceiling, and the roof remained unpainted except in the chemical laboratory. The special agent in charge drew the plans, prepared the specifications, and gave the work his personal supervision during construction, in order that the structure should be properly built. In addition to the laboratory building, the insular authorities appropriated $1,500 for a residence for the chemist. This was built by contract, but when turned over to the station was not suitable for occupancy and it required an expenditure of several hundred dollars to complete the work. In addition to these buildings, a number of necessary repairs have been made, and 1,000 feet of 2-inch pipe has been added to the water system of the station. The water supply from the city was extended by substituting 960 feet of 3-inch pipe for the same amount of 2-inch pipe on the central water main, thus making it possible to get city water 50 feet higher on the station grounds than before. A new 10,000-gallon tank for water supply for the residences was constructed and the one previously built was moved to a higher elevation, which results in an increased supply of water.

THE WATER PROBLEM.

With the extension of the water pipe and the building of new tanks some of the immediate necessities of the station are supplied, but as long as the station must depend on the Honolulu city water for irrigating purposes the supply will be inadequate to our needs. The tanks which have been depended upon for water supplies for the residences furnish only an amount sufficient for domestic purposes and offer little or no protection from fire. At present the buildings are without fire protection, as they are at a considerable distance from the Honolulu fire service. In order to meet the necessity for a more certain supply for irrigation purposes as well as to provide fire protection, a number of alternative plans have been drawn which contemplate the impounding in some way of the water at the higher level of the station grounds and conducting it to the lower lying tracts. At an elevation of 1,375 feet, on the upper part of the station grounds, there is a rainfall of more than 100 inches annually, while at the lower part of the station grounds, at a 100-foot level, the rainfall is only about 30 inches. It is believed that the abundant rainfall at the higher elevation could be collected in some way and applied to the lower part of the station, where it is impossible to carry on agricultural and horticultural operations without a permanent and adequate water supply. It is to be hoped that Congress will grant a special appropriation for supplying the necessities of the station in this respect.

FUNDS.

The appropriation made by Congress for the fiscal year 1905 was $15,000. In addition to this, Territorial appropriations were made amounting to $7,236, and the proceeds of sales of products of the station amounted to $1,153.70, making the total income from all sources

$23,389.70. The Territorial appropriations were for carrying on investigations in cooperation with the board of agriculture and forestry, and specific appropriations were made of $1,500 for the erection of a residence for the chemist, and $3,000 for a fireproof library, laboratory, and office building. The law specified that the latter building should be fireproof, but the sum appropriated was absolutely inadequate for a fireproof structure. As the money appropriated would lapse if not used during the fiscal year, the special agent believed it his duty to proceed with the building operations and complete them with funds derived from the other resources of the station. In doing this he used $3,487.30 for buildings and repairs, and $698.68 for fitting up the chemical laboratory, and $508.28 for reference books for the library. The amount spent for labor during the year was $3,369.57. The last session of the legislature adjourned without making any appropriation directly to the station, so that for the ensuing biennial period it will be dependent upon the amount appropriated by Congress and the sales of farm products.

INVESTIGATIONS.

The scientific work during the past year has been somewhat hampered by the construction operations before described. Nevertheless, a good deal has been accomplished. In cooperation with the Hawaiian Live Stock Breeders' Association a large amount of seeds of various grasses and forage plants were secured and distributed. Sufficient time has not yet elapsed to determine the success of this experiment, but it has already shown that fenugreek, Spanish sulla, woolly top (*Andropogon saccharoides*), and *Panicum bulbosum* are adapted to Hawaiian conditions. These recent introductions, together with others previously brought in by the station, are recognized by stockmen as having been of great value in restocking and extending their ranges, and this work will be continued for some time.

TAN-BARK PRODUCTION.

During the past year the special agent caused to be cut about 6 acres of black wattle (*Acacia decurrens*), which was growing on the station grounds at an elevation of about 700 feet above sea level. The soil at this place is a heavy decomposed lava, with frequent outcroppings of rock, and the slope is too steep to permit of any cultivation. The forest was planted about 1890 under the direction of the minister of agriculture of the then Hawaiian government, but had become overgrown by lantana. In addition the trees had reached full maturity and were beginning to die, about 10 per cent having died during the previous year. A galvanized-iron drying shed 30 by 50 feet was erected, and a force of laborers was hired to cut down the trees and strip off the bark. A period of drought occurred while the bark was being stripped, so that many of the trees could not be successfully peeled. The bark strips were bundled and carried to the drying shed either on sleds drawn by horses or by wire trolley. A number of experiments were made to determine the cheapest commercial methods of handling the bark, which must be dried, chopped, and bagged before being marketed.

The station harvested from this tract 36 tons of dry bark, which was sold in Honolulu for $839.44, or at an average of $23.31 per ton. Twenty-five tons were shipped to Japan and the remainder was marketed in Honolulu and San Francisco. In addition to the bark the station secured 88 cords of firewood, which was sold to dealers in Honolulu for $689.25, or an average of $7.83 per cord. The total yield of bark and wood was at the rate of $254.84 per acre. In addition about 500 fence posts have been cut from the wattle grove during the past four years. The bark averaged from 28 to 37 per cent in tannin, and had it been sold according to the tannin content, or had there been a larger amount to market, better prices would undoubtedly have been obtained.

The special agent believes that wattle bark cultivation would prove a profitable industry in parts of Hawaii, as the trees grow as well in Hawaii as anywhere in the world. A yield of 6 tons of bark per acre would be considered a very low average, but if the trees were planted at a distance of 6 by 10 feet an acre should yield from 6 to 12 tons of tan bark in ten years, together with 30 cords of firewood. If wattle bark is to be produced on a large scale, the special agent believes that in preparing the bark for market it would pay to install a large, well-ventilated drying shed, with a tight roof and a number of stages of removable flooring, so as to cut the bark green, distribute it in thin layers, and dry quickly under shelter. This is contrary to the practice in Natal, where artificial plantations are maintained, but the climate of Hawaii is such that the bark can not safely be dried out of doors at the elevation where the trees are likely to be grown. The value of the bark would depend on its being protected from rain during the drying processes, as the tannin is readily washed out by water. Furthermore, the bark cuts better green than dry. The initial cost of drying sheds would be greater, but the probabilities are that the product would be more uniform and of a higher grade. It is believed that wattle cultivation would prove extremely profitable if a sufficient acreage were planted to enable the owner to market a definite amount of tan bark every year after the plantation reaches maturity. A bulletin (No. 11) upon this subject has been published by the station.

TOBACCO EXPERIMENTS.

In the autumn of 1903 a cooperative experiment was arranged under the joint auspices of the Territorial Board of Commissioners of Agriculture and Forestry and the Hawaii Station for the purpose of demonstrating the practicability of growing the best grades of cigar tobacco in Hawaii.

An examination of sites was made by Mr. F. E. Conter, formerly connected with the station, who, in the beginning, had charge of the work. Mr. Conter visited the Puna, Hilo, Hamakua, and Kona districts of the island of Hawaii, and finally selected a small tract on the Louisson Brothers' plantation on the lands of Pohakea, Hamakua. A lease of 2½ acres of the land was secured and special privileges were granted by the owners of the land, who have assisted the enterprise in every way in their power. The land was new and uncultivated, so that a delay of some months ensued before the field could be made ready for planting. The first crop was transplanted to the experimental plats in March and April, 1904.

The experimental tobacco field was located in Hamakua because the physical character of the soil was believed suited to the production of a good quality of crop. The Pohakea homestead lands were suitable, available, and convenient. There are doubtless other areas in Puna, Kau, and Kona, on the island of Hawaii, and on each of the other islands of the group, but at the time this experiment was undertaken the Pohakea tract was selected as the most convenient place in which to carry on field work.

SOME HAWAIIAN TOBACCO SOILS.

The texture of a soil—that is, the ratio between clay, silt, fine and coarse sand—is held to have much to do with the type of the product, and the color of the cured leaf, whether light or dark, its thinness and elasticity, depend, apparently, on soil characteristics and its water-holding capacity.

The soil on the Hamakua homesteads and on the Hamakua tract of land adapted to tobacco—a belt extending from Paauhau to Hakalau, at an elevation of from 1,000 to 2,500 feet—is a sandy forest loam, very rich in humus and with a high nitrogen content. The color of the soil is a light brown, becoming almost black when wet. The following physical analyses, made by Dr. Edmund C. Shorey, show the characteristics of these soils, and for comparison there is included an analysis of Sumatra soil, made by the Bureau of Soils of the U. S. Department of Agriculture.

Physical analyses of some tobacco soils.

Constituents.	Pohakea.	Kailua, Kona.	Rimboen, Sumatra.
	Per cent.	*Per cent.*	*Per cent.*
Organic matter and water	35.935	30.82	23.41
Gravel	16.511	11.85	.81
Coarse sand	11.337	13.25	1.44
Medium sand	6.716	3.95	3.62
Fine sand	14.002	8.42	13.94
Very fine sand	8.339	28.25	19.52
Silt	5.848	1.75	23.51
Clay	.940	.85	2.72

A chemical examination of the Pohakea soils showed that although the "iron and alumina" content is high the percentage of clay is very low. The "fine gravel" and "coarse sand" are really reducible to "fine sand" and "very fine sand" if the soil is shaken in water for longer than the customary period previous to analysis. There is almost no true clay in this soil, and practically no true gravel or coarse sand.

The lime is present as a silicate and is too low in quantity to neutralize the acidity. The potash content is very low. Nevertheless, a dressing of sulphate of potash applied to the experimental plats at the rate of 500 pounds per acre produced cigar leaf of exceptionally good burning qualities. The nitrogen, although high, is largely unavailable, so that it will pay to use moderate amounts of nitrate on the crop. The phosphoric acid is presumably largely unavailable.

On cultivation the coarser particles of Hawaiian soils rapidly disintegrate. The shotty particles, technically classed as "fine gravel" and "coarse sand," when worked with rubber pestles or rubbed between the fingers are easily crushed to a fine powder. The ultimate soil grains are agglutinated in masses because of the exceptionally large percentage of organic matter in the soil.

The tobacco soils of Hamakua and Kona are very similar in all their characteristics, and probably the Kona district is better adapted to tobacco cultivation than Hamakua because of the protection from strong trade winds.

CLIMATE.

The influence of climate on the growing of tobacco is always held to be a potent factor. Cigar tobaccos of good quality are produced through a wide range in latitude. Proximity to the ocean has always been considered a deterrent influence.

Tobacco requires from 70 to 100 inches annual rainfall, from one-half to one-third of this during the growing season. Moderate temperatures, frequent showers or irrigation, to promote even, uninterrupted growth, neither too rapid nor too slow, constitute an important element in determining the suitability of any district where soil conditions are correct. The slight variation of daily and seasonal temperatures is characteristic of Hawaii, so that the rainfall or the ability to irrigate the crop when required become of greater importance than any consideration of actual temperatures.

In the windward districts protection from wind must be provided (Plate I, fig. 3). This may be accomplished either by tenting the field with cotton cloth, as in Connecticut and Florida, or permitting the larger ohia trees to remain when the land is cleared; or, in case tobacco is planted on lands cleared for cane or other "open-field" crops, by planting or constructing suitable wind-breaks. In the leeward districts the protection from wind may be neglected.

After comparison of results in Hawaii with those obtained elsewhere in growing tobacco of fine quality, it is believed that uniformity of temperatures, with sufficient moisture during the growing season of the plant, have as much to do with the quality of tobacco as any other physical or climatic factor. If this be true, the remarkable monotony of temperatures and narrow variations, daily, monthly, and seasonal, should make it possible to grow in Hawaii fine tobaccos which will in time be classed as distinct from those of any other land.

CULTIVATION, CURING, ETC.

One of the main requisites for success in tobacco culture is to have good, strong, healthy plants ready to transplant to the field at the proper time. Good seed is the first essential in their production, for without good stock to start with, one can hardly expect to obtain the best results.

An open seed bed, as is used in other countries, would prove a failure in Hawaii. Insects are too numerous and the soil too full of humus to stand burning. Two methods can be recommended. The first of these is elevated boxes, set about 20 inches from the ground on posts, the box level and projecting at least 6 inches outside the posts, 3½ to 4 feet wide, 10 to 12 feet long, and at least 6 inches deep. Fill full with good soil, sifted to remove sticks, trash, and stones, the last inch being finer, so that the seed, which is very small, may come in closer contact with the soil, but not be covered too deeply. Add a pound or two of air-slaked lime and mix well with the last 2 inches of top soil filled into the boxes or beds. The seedboxes, when the seedlings show up, should be covered with a gable-roofed frame, covered with cheese cloth or light, open cotton. This cover retains the moisture, maintains a more nearly uniform temperature, and wards off insects.

The other method is to build a large cloth house, with gable roof, and in it arrange the beds so as to permit ready passage among them. The elevated boxes, for a few plants, are the easier to make and care for. In an excessively rainy period the boxes do not drain off the water as well as the beds and become cold and soggy. For growing a large number of plants the seed house is to be preferred.

All seedboxes and beds should be sterilized to kill insects and their eggs. An easy way to do this is to use from 10 to 20 gallons of boiling water, applied as evenly and quickly as possible and cover with some kind of a blanket to retain the heat. A pair of saddle blankets answers the purpose nicely.

After the seed beds become cold they are ready for the seed, and if the top has become packed it should be loosened and made fine.

Tobacco seed should be sown thinly, so the plants have room to grow. Each plant should have at least 1 square inch of surface to make a sturdy plant. Seed beds should, at all times, be fairly moist, and never be allowed to become dry or to show dryness on the surface. The seed is small and is only planted on the surface. Good seed should germinate in from twelve to fifteen days. In from six to eight weeks the more hardy plants will be ready for the field, and the others will follow in quick succession until the bed is exhausted of all desirable plants.

Young plants should be allowed considerable sunshine to harden them before transplanting.

PLOWING AND TRANSPLANTING.

The land selected for a tobacco field should be such as can be plowed both ways. It should be sheltered from the high trade winds that sometimes blow with great force. Small square plats of from 2 to 5 acres each would form good fields for a small planter, especially if surrounded by the forest. It is well to plow the land some little time in advance of the planting.

Tobacco being a tap-rooted plant, in some instances sending its roots down to a depth of 2 feet or more, requires that tillage shall be deep in preparing the land to receive the young plants. The soil should be plowed to a depth of at least 12 inches, and the work should be done in such a manner that the subsoil is not brought to the surface. Have the soil fine and loose but leave the sterile, acid subsoil underneath where nature placed it. Put the soil in good, mellow condition, as it pays to do so for any crop.

As soon as the land is plowed and harrowed, the field should be poisoned to kill pokos or cutworms (Plate I, fig. 4), army worms, Japanese beetles, and the various pests usually abundant in newly turned land. There are two remedies which are of about equal value. Sow one or the other of the following broadcast over the newly plowed land:

Arsenicated horse manure.—To 40 pounds of dried, fresh horse manure, as free from straw as possible, add 6 to 8 ounces Paris green mixed with 5 pounds of common salt. Stir until the salt and Paris green are thoroughly incorporated in every part of the manure. This amount is sufficient for 1 acre.

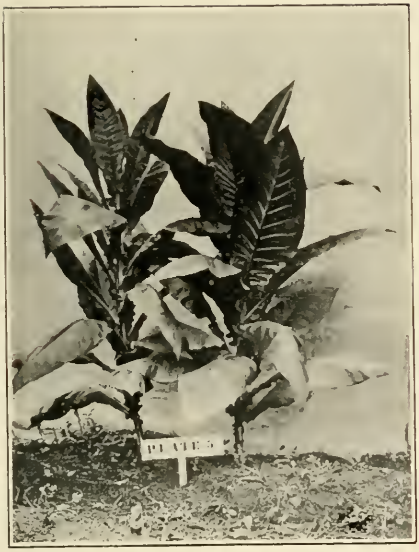

FIG. 1.—HAVANA SEED LEAF, PLANT 3 FEET 9 INCHES HIGH.

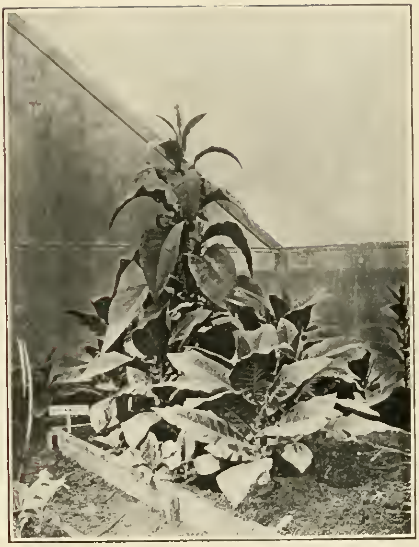

FIG. 2.—VUELTA ABAJO, UNDER SHADE, PLANT 6 FEET 6 INCHES HIGH.

FIG. 3.—PLAT OF YOUNG PLANTS.

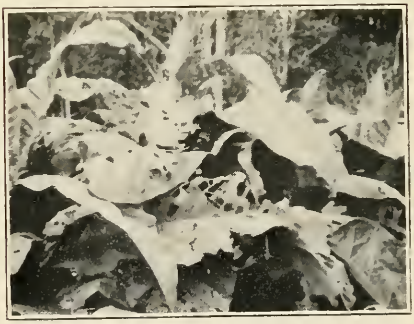

FIG. 4.—WORK OF CUTWORMS ON LEAVES.

Poisoned bran.—To 2 pecks of bran or coarse corn meal add 4 ounces Paris green or 8 ounces disparene and 2 quarts of molasses or honey or 5 pounds coarse sugar. If sugar is used, moisten the bran with water. Stir and mix thoroughly and scatter over the field.

Poisoned horse manure is safer than poisoned bran and somewhat cheaper. Pokos and army worms like it fully as well as the sweetened bran, and cattle, chickens, and other domestic animals are less liable to be poisoned through eating it. The Japanese beetle seems to prefer the poisoned bran.

The field being prepared and the plants ready, they can be set out at any time of the year when the soil is in a moist condition and the sky is clouded. Plant only good, strong, healthy plants in the field. It is poor economy to set a sickly plant anywhere and give it care and cultivation, with but little chance for a return from it for the time and labor expended.

If the sun is shining when the seedlings are transplanted, the young plants need some shade until they start. Ti leaves make a good shade. Stick the stem end into the ground and bend it over the young tobacco plant and fasten the other end with a handful of soil laid upon it.

In Hamakua tobacco can be set at any time and will grow, but it will grow better and faster from February to September (warm weather), although, if set in September and October, if the ground is wet, it will make enough growth to mature a crop during the cold weather.

Care should always be used in handling young tobacco plants, as the leaves and shoots are very brittle and tender and break easily. Tobacco should be planted on slightly raised ridges, some 3 or 4 inches higher than the surrounding ground, as it facilitates drainage and places the plants in a more decided position and less liable to injury through cultivation.

The distance between the plants in the row and the width of the rows is governed by the kind of tobacco planted and the use to which the finished leaf is to be put, whether wrapper or filler. The right distance to plant must be determined by each planter to suit the type of tobacco grown and the character of the soil. In Hamakua the cigar tobaccos, such as the Cuban, Sumatra, Connecticut Seed Leaf, and Zimmer Spanish, do well 15 inches in the row and 3 feet 5 inches between rows. An acre set at this distance contains about 10,000 plants. The manufacturing tobaccos, producing a larger leaf, require more room each way and should be set 2 feet 4 inches apart in rows 4 feet apart.

In about seven to eight weeks after setting in the field the plant will send up a head or seed cluster, which should be removed in all cases before any of the flowers open.

HARVESTING AND CURING.

Between the time of planting and harvesting a tobacco barn must be provided large enough to care for the entire crop. This structure should be of lumber rather than galvanized iron, with shingle roof, hinged frieze, or gable ventilators, and the sides provided with vertical ventilators extending from sill to plate, the idea being to secure complete control of temperature and air drafts within the building during the curing process.

A tobacco barn, properly constructed, should last for twenty years. In Hamakua, at the elevation where our tobacco experiment is being conducted, a stove must be provided to heat the air and control moisture because of the frequent periods of fog and cloudy weather. This stove is placed outside of the shed, with the pipe or flue passing either across through the house from side to side or, inside a large barn, around two or more walls.

In Hamakua the curing process requires from two to four weeks. The determination of the proper time to harvest tobacco leaves is a matter of judgment and experience. Leaves that are underripe cure greenish, thin, papery, and brittle. Those overripe become harsh, thick, and of uneven color. A ripe leaf cures gummy, pliable, elastic, and of an even color.

Each kind of tobacco has its special characteristics and must be treated accordingly. Cigar tobaccos require slower barn curing and more careful manipulation during the whole period of growth, curing, and fermentation than do the cheaper grades of manufacturing and export tobaccos.

The fermentation of the tobacco follows the curing. This is a very important step in the process and is fully described in Press Bulletin No. 12 of this station. In Hawaii the period of fermentation lasts sixty to ninety days. Five pounds of green leaf produce about 1 pound of finished tobacco.

RESULTS OBTAINED AT HAMAKUA, 1904.

The crop planted during March and April, 1904, was the first systematic and scientific attempt to grow tobacco in Hawaii. An acre was covered with an open-weave cotton cloth, Ariel tenting cloth, put upon plates and posts, forming a flat roof about 9 feet above the ground; the sides were also covered with the same kind of cloth, making a tight inclosure. This covered plat, with some land adjoining, about 1¼ acres in all, was planted as follows: Sumatra, Florida and Long Stem; Cuban, Florida and Vuelta Abajo; Connecticut Broad Leaf and Seed Leaf; Zimmer Spanish; Virginia Dark Leaf; White Burley; and Japanese.

A good many plants under the cloth shelter were killed by the drip from the seams, wires, and plates of the structure. This first year's work demonstrated quite clearly that tenting tobacco is not a success in Hawaii, at least in regions of high rainfall.

The following field notes may be of interest and value:

Sumatra.—Sumatra tobacco averages 8 to 9 feet in height and tops at about 7 feet. One thousand plants produced 19,309 leaves, weighing, green, 684 pounds, or 137 pounds of finished tobacco. The average per plant was 19.3 leaves, weighing 11.5 ounces, and the estimated yield per acre containing 9,680 plants was 6,332 pounds of green leaf, which would make 1,260 pounds of finished tobacco.

Florida Cuban.—This tobacco grows 5 to 7 feet in height and tops at 4½ to 5½ feet. Each plant yielded on an average 10.6 leaves, weighing, green, 6.8 ounces. Florida Cuban tobacco will stand planting 15 inches apart in rows 3 feet apart, or at the rate of 11,500 plants to the acre. The estimated yield per acre on the basis of the yield obtained is 4,870 pounds of green leaf, or 970 pounds of finished tobacco.

Vuelta Abajo, Cuban.—This is a low-growing tobacco, averaging about 4½ feet and topping at 3 to 3½ feet. (Plate I, fig. 2.) Two hundred and ten plants yielded 1,500 leaves. The average per plant was 7.2 leaves, weighing, green, 3.4 ounces. This tobacco would stand planting 12 inches apart in rows 3 feet apart, or at the rate of 14,500 plants per acre. The estimated yield per acre is 3,080 pounds of green leaf, or 616 pounds of finished tobacco.

Connecticut Broad Leaf.—This tobacco grows 4 to 6 feet tall and tops on an average at 3 feet 8 inches. Some of the leaves were 37 inches long by 16 wide. The average per plant was 15.1 leaves, weighing 1 pound. This tobacco is planted 18 inches apart in rows 42 inches apart. It should have been spaced wider, at least 30 inches in the row and 48 inches between rows. Our yield was at the rate of 7,820 pounds of green leaf or 1,560 pounds of finished tobacco. Connecticut Broad Leaf is difficult to cure because of the extraordinary thickness of the midrib and lateral veins. None of the other varieties of tobacco grown were weighed or measured.

Connecticut Seed Leaf cured lighter than any of the other tobaccos and gave a thin, light leaf, fit for wrapper. In the curing shed this molded very badly. *White Burley* would not cure or even dry without molding. It will require a high heat to cure. It is a pipe tobacco and is also, to some extent, used as a filler in cheap, domestic cigars.

Japan tobacco is about the same as the Broad Leaf, a wide leaf, not quite so long but with a large midrib. It is a pipe or cigarette tobacco.

Zimmer Spanish cured very dark, harsh, dry, and brittle, and did not absorb much moisture even in a rainy time. It is used for filler in the cheaper grades of domestic cigars.

After curing and fermenting the crop, samples were submitted to a number of experts and cigar manufacturers and the quality of some varieties was pronounced excellent. This was especially true of the Cuban types, cigars made from this crop equaling many of the well-known brands of Key West and Cuban cigars. A prominent Philadelphia manufacturer, reporting on samples submitted, says: "The burning quality of your sample is exceptionally good. In our estimation it makes a finer smoke to mix with Havana tobacco than any of our ordinary domestic tobaccos to-day on the market, and by all means the pleasure and taste is very much superior to tobacco grown in Florida, which is now so successfully used by numerous manufacturers in Tampa and Key West posing as clear Havana manufacturers."

HAMAKUA EXPERIMENTS, 1905.

The results indicated at the close of the season of 1905 are that wrapper tobaccos of fine texture and body, and filler leaf of mild flavor and good burning qualities, are a commercial possibility. The chief fault to be overcome lies in the direction of the production of light colors, the greater percentage which have been produced being of shades darker than the present market fashions demand. In flavor the filler types are intermediate between the Manila and the Cuban, so that if producers undertake this industry on a practical scale, the indications are that the Hawaiian leaf can be marketed, to a certain extent, on its own merits, rather than in competition with either the Cuban or the Manila cigar tobaccos. As the color of the finished product can be almost absolutely controlled by the method of cultivation and of manipulation in curing and fermentation, that phase of production need not be considered a serious drawback. While at the beginning of the experiment artificial shade by the use of tenting cloths was attempted, the 1905 crop was grown in the open, entirely without shelter other than that due to the fact that the experimental plat is surrounded on all sides by forest, and the indications are that tenting is absolutely unnecessary in Hawaii. It so happens that the districts having tobacco soil in considerable area are mostly located at an elevation of from 800 to 2,000 feet, which zone constitutes the so-called cloud belt of the islands. While it does not rain every day, the clouds gather on this portion of the mountain slope almost invariably during each afternoon, while the mornings are bright with clear sunshine. It is believed that the natural climatic conditions together with the physical conditions of the soil are the causes which lead to the production of filmy texture and silkiness, with elasticity—the characters absolutely essential to wrapper leaf of high quality. In addition to the wrapper and filler leaf, a crop has been grown of broad-leaf tobacco of the binder type, in regard to the quality of which experts have made extremely favorable reports.

About 20 per cent of the crop of Sumatra tobacco grown in 1905 was of excellent quality as regards texture and body, while only about 10 per cent of the whole crop showed desirable shades of color. This 10 per cent has been valued by tobacco experts as worth from $2 to $4.50 per pound. The yield in the experimental plats has been at the rate of about 1,000 pounds per acre. The balance of the crop, unsuited for wrappers, commands only a very low price, perhaps on an average not more than 10 cents per pound. The tobaccos of the Cuban type (Pl. I, fig. 1) yield considerably less than tobaccos of the Manila, Hawaiian, Japanese, and Sumatra types, but whatever percentage is left after the wrapper leaf has been selected is salable as filler at prices ranging from 15 to 40 or 50 cents per pound. The yield of Cuban leaf ranges from 450 to 600 pounds per acre, and fully 25 per cent of the 1905 crop would have been suitable for wrapper leaf had the colors been lighter.

There are at least 100,000 acres of land in Hawaii where the physical character of the soil is right for growing tobacco. The largest areas are on the island of Hawaii, in the Hamakua, Olaa, Puna, Kau, and Kona districts. There are also available tobacco lands on Maui, in the district between Makawao and Ulupalakua, and smaller areas on Oahu and Kauai.

An estimate has been made that if a grower produces tobacco on his own land, and with his own labor or that of his family, the green leaf can be produced at a cost of about 2 to 2½ cents per pound, equal to 10 to 12½ cents per pound for barn-cured tobacco.

The yield of Sumatra tobacco ranges from 750 to 1,000 pounds of cured leaf per acre. The broad leaf binder types yield from 1,000 to 1,400 pounds, and the Cuban filler and wrapper types from 450 to about 600 pounds.

Unless growers have a considerable acreage they can not themselves ferment their crop to the best advantage. This end of the industry will undoubtedly have to be handled by corporations. While knowledge of tobacco curing in other countries will be extremely valuable to those entering upon this industry in Hawaii, nevertheless the climatic requirements are such that local agricultural experience will be of almost equal value. The old Hawaiian native or Manila type of tobacco grows wild all over the islands, from sea level up to the frost line. It has been grown so long without cultivation, or with only the crudest care, that the plant has apparently reverted to the original type. The leaves cure a very rich brown color, but are thick, heavy, and leathery, with so much gum that even after being fermented the burn is very poor. The old Hawaiians, however, recognize certain limited districts as producing tobacco of flavor and strength suitable to their requirements and taste, with burning qualities which are better than the average.

These districts are in almost all cases quite near the ocean. They are located near Hana, Maui; in certain localities on the island of Niihau; in Kona and Kohala, on Hawaii, and in the vicinity of Waimea, on Kauai. Tobacco cultivation was also at one time a considerable industry among the native Hawaiians in the district around Naalehi, in Kau. The best grades of these Hawaiian tobaccos are sold to natives and Chinese at the rate of 25 cents for twenty-two leaves, or at about 50 cents per pound.

The outlook for the tobacco industry in Hawaii is very good. While to a certain extent a market must be created before the production of filler types of tobacco is undertaken on a large scale, there is sufficient demand for wrapper leaf of the better qualities to make the cultivation of these types of tobacco a sure success, even though the crop must be marketed in open competition with leaf imported into the United States from Cuba and Sumatra.

RUBBER CULTIVATION.

The cultivation of rubber-producing plants is engrossing attention in all tropical lands, and recently many inquiries have been received at the station as to the species most liable to prove a successful introduction into Hawaii. To supply this information the special agent in charge prepared a press bulletin based upon observations on specimen trees growing in various parts of the islands and upon recent articles in journals devoted to tropical agriculture. Hawaii, with its subtropical rather than thoroughly tropical climate, is probably limited to a few species of rubber-producing plants. Of the better known species two have been shown to be adapted to Hawaiian conditions, the Ceara rubber (*Manihot glaziovii*) and the Assam or common rubber tree of gardens (*Ficus elastica*). In favorable situations the Ceara rubber trees will make a rapid growth in Hawaii, apparently thriving from sea level to 2,500 feet elevation, both on the wet and dry sides of the islands. There are a number of trees of this variety growing on the station grounds that were planted in 1893. One of the best specimens stands in a clearing near the Tantalus road, where it received some spasmodic attention. This tree is now 40 feet high, with a trunk 10 inches in diameter. Others planted at the same time, but totally neglected and overrun by lantana and shaded by eucalyptus, are only 10 to 15 feet in height and an inch or two in diameter. The Assam rubber is somewhat slower of growth in Hawaii, but it is believed to be one of the most promising rubber trees for plantation culture in such districts as Hilo, Puna, Olaa, and Nahiku. This species will withstand low temperatures, that are extremely detrimental to Para and Central American rubber trees.

From what is known regarding the adaptability of rubber trees in

Hawaii, it is believed that the Ceara rubber tree should comprise the larger proportion of all new plantations, because of its extremely rapid growth and early maturity. In laying out a rubber plantation comparatively early returns are desirable. The Ceara trees will stand a moderate tapping, when three years old, and may be counted on to yield a considerable return in five years. The Assam rubber tree, while of much slower growth, yields much more abundantly when it does finally reach bearing age. A number of other varieties are believed worthy of trial, as they are reported native of high elevations where the climatic conditions are similar to those of the Hawaiian mountain slopes. The conditions in Hawaii are believed to be extremely favorable for the cultivation of Ceara rubber trees, and one of the newly formed companies has already planted 100,000 seeds of this species and expects to have half a million trees growing within two years. It is believed that with as much science, skill, and knowledge devoted to rubber planting as is now given the sugar industry there will be no question of ultimate success in this new industry.

CASSAVA.

Considerable attention has been recently given throughout tropical and subtropical regions to cassava cultivation. This plant is well known to the native Hawaiians as a food plant, bearing the name pia, which was used by the older generation for the native arrowroot (*Maranta arundinacea*). While cassava is used for forage and as a vegetable, its more important use is for the preparation of starch, known commercially as tapioca flour. There is one small factory in operation on Kauai, but the plant is not a modern one and the business is conducted rather as an adjunct to cattle feeding.

In Hawaii cassava grows as a perennial, although commercially it is best to treat the crop as an annual. It thrives from sea level on the Kona side of most of the islands up to 3,000 feet elevation, except in very wet districts. It requires about the same soil as sweet potatoes and maintains an existence for a surprisingly long time, even under the most adverse conditions of neglect. A few plants are usually to be seen in the gardens of native Hawaiians, who give them less care and attention than they bestow upon their sweet-potato crop. If the production of this crop is undertaken on a commercial scale, the land should be selected so that it can be given the proper cultivation. Shallow plowing, 6 to 12 inches, is preferred to deeper cultivation, as it tends to keep the roots nearer the surface and facilitates harvesting. After the land is thoroughly prepared the seed, which consists of cuttings of the stalk, are planted in furrows 2 to 4 feet apart. The best results obtained in Hawaii are from plantings made from November to February. A field should be cultivated sufficiently to keep down the weeds, and at the end of the wet season the plants will be high enough to care for themselves in this respect. No irrigation is required, but a moderate application of low-grade fertilizer is recommended. As Hawaiian soils are mostly lacking in potash, this element should be used rather freely.

When planted as directed above, the roots will be ready for harvest the following October or November. The roots will remain for a long period in the soil, and if allowed to grow for two years will greatly increase in size and weight, but the increase is at the expense of the starch. The two-year-old roots are often hard and fibrous, containing little starch. Cassava rots quickly after being dug, seldom keeping for more than a week. However, as long as the roots remain in the ground they will not rot unless the plants are diseased. Mice, borers, and field cockroaches attack the roots, and on this account it is believed advisable to treat cassava as an annual. A yield of 5 tons of cassava roots per acre is about an average, although yields of from 5 to 10 tons may be counted on in good land with favorable seasons.

It would seem that the cultivation of cassava for starch or glucose manufacture might be profitably carried on in connection with the fattening of cattle and hogs for market. The area available for the cultivation of cassava in Hawaii is large, and it is a crop which does not require large investments for the field operations of plowing, planting, cultivation, and harvesting.

PUBLICATIONS.

During the year three regular bulletins and four press bulletins were issued.

Bulletin No. 8, Methods of Milking, describes the Hegelund or Danish method of milking and gives the result of a thirty days' trial of this method at the Kamehameha Boys' School dairy.

Bulletin No. 9, Citrus Fruits in Hawaii, gives the results of investigations by the horticulturist of the station into the present condition of citrus-fruit growing and suggests methods for the restoration and development of this industry. In addition to describing standard varieties of various citrus fruits the author calls attention to a number of native seedlings that are believed worthy of more extended propagation.

Bulletin No. 10, Insect Enemies of Tobacco in Hawaii, gives an account of the insect enemies of tobacco in Hawaii and suggests methods for their control.

Press Bulletin No. 11, The Common Liver Fluke in Hawaii, calls attention to the common occurrence of liver flukes in cattle, sheep, and other domesticated animals, and, after describing the parasite and symptoms of the disease, suggests methods for its control.

Press Bulletin No. 12, Tobacco in Hawaii, gives an account of experiments carried on by the station at Hamakua, Hawaii, in growing tobacco. The experiments, which had been in progress for but a single year, seemed to indicate the possibility of growing cigar tobacco of good quality in certain regions of the islands.

Press Bulletin No. 13, Rubber in Hawaii, gives compiled information regarding the rubber-producing trees and vines of the world, describes specimens already growing in the islands, and gives suggestions for planting and cultivating rubber trees.

Press Bulletin No. 14, Fuller's Rose Beetle, describes one of the most injurious beetles of Hawaii, where it is known as the "Maui" or "Olinda beetle." It feeds on a wide range of economic plants, and remedies are suggested.

REPORT OF THE CHEMIST.

By E. C. Shorey.

The beginning of the fiscal year 1905 saw the chemist still occupying the small building serving as office, library, and laboratory. In the temporary laboratory fitted up in this building the soil work and preparation of fodder samples, noted in the last report, was continued.

In the case of fodder samples the method of preparation was as follows: A weighed quantity, usually 500 grams, of the green fodder was chopped and air dried, weighed again, the loss on air drying being recorded. The whole of the air-dried sample was then ground and passed through a 0.5-millimeter sieve, and a portion stored in an air-tight sample bottle. Quite a number of samples so prepared were rendered useless for purposes of analysis by the ravages of the cigarette beetle (*Lasioderma serricorne*). In some cases the beetles made their appearance three weeks after the samples were stored. This preparation of fodder samples and a continuation in a small way of the work on soil nitrogen was the only work done in the temporary laboratory.

NEW LABORATORY.

The new laboratory was completed in October, and moving in and fitting up took about one month. The water and gas pipes and some shelving not included in the contract were put in with station labor. The main room of the laboratory is 25 by 35 feet, with a small nitrogen room partitioned off from one corner. Adjoining the main room are three small ones—an office, a balance room, and a dark room. The main room is well supplied with worktables, sinks, and hoods. There are sinks and hoods in the nitrogen room and a sink in the dark room. The worktables are well lighted, and with a slight increase in equipment it would be possible for three chemists to work without inconvenience. The present gas supply is that furnished by the small gas machine used in the temporary laboratory, and the supply is so small that work is practically confined to one thing at a time. The Honolulu Gas Company is at present laying mains in the city, and it is hoped that they will soon have a main near enough the station for gas to be obtained from that source.

A few additions of standard reference works were made to the library during the year. Among these was a complete set of Hoppe-Seyler's Zeitschrift für physiologische Chemie.

LABORATORY WORK.

The laboratory work may be divided into three classes: (1) Routine work; the analysis according to official or well-approved methods of materials, such as soils, fertilizers, and fodders, to determine total or partial composition. (2) Miscellaneous work; the examination of samples of a miscellaneous character to determine composition, value, or adaptability for special purposes. This work for the most part is undertaken at the request of individuals, and quite often the satisfactory answer of such inquiries entails research work, the devising of new methods of analysis, search for new compounds, or the application of known facts in explanation of new or little understood conditions. (3) Research work proper. The work done in the new laboratory from November, 1904, to June 30, 1905, may be noted under these three heads, as follows:

ROUTINE WORK.

This was confined to analysis of fodder samples. These analyses were made by the official method, and, in addition to the usual analysis, determinations were made of albuminoid nitrogen, potash, lime, and phosphoric acid. The object in making these analyses was to furnish material for publication on the composition of Hawaiian-grown fodders, and, in the meantime, supply data sufficient to answer some of the frequent inquiries which come to the station regarding the composition of such material. Sixty-three samples were analyzed, the more common fodders being represented by from two to six samples. A large number, however, are as yet represented by but one sample each. As quite a number of fodders, especially grasses, are as yet not represented in this series, and as in nearly all cases the samples are too few to establish maximum, minimum, and average composition, it is the intention to continue this work during the coming year. It is also the intention to complete the ash analyses of these samples, and it is hoped to supplement the analysis of Hawaiian-grown fodders by feeding experiments, in cooperation with individuals or institutions having dairy or other stock.

MISCELLANEOUS WORK.

Fifty samples of soil have been turned in to the laboratory, sent either by private individuals or collected by members of the station staff in various parts of the islands. Fifteen of these samples have been examined and reported on. In a number of cases the samples were of such a character or the data supplied were so meager that time spent on them would have been wasted. In such cases further information and reliable samples have been sought. Twenty samples of those on hand will be examined as rapidly as the facilities of the laboratory will permit. The soils examined include those devoted to tobacco, bananas, and cacao on Hawaii and pineapples on Oahu. The official method, digestion with hydrochloric acid, specific gravity 1.115, has been used throughout, and in giving advice based on these analyses due regard has been given the various factors bearing on this matter noted in the last report.

Three samples of honey, marked, respectively, grades 1, 2, and 3, were submitted by a local producer with the statement that the price obtained had not been as good as expected, and asking if analysis would show any difference in the samples or anything to justify the buyer's objection to the quality. Analysis showed almost the same composition, except in moisture content, the figures being as follows: No. 1, 15.79 per cent; No. 2, 17.34 per cent; and No. 3, 18.70 per cent. It was learned after reporting as above that the buyer objected to the amount of water in the lower grades, and it was suggested that this was due to uncapped or partially capped unripe honey being included in those grades.

The manager of a local cannery making guava jelly reported that a portion of the season's output was unsalable, owing to the more or less liquid condition of the article, and that in the same lot some jars were of good quality and others made in the same way were defective. Samples were submitted, but analysis did not disclose any reason for this behavior. It was evident that a remedy for this trouble could be arrived at only by a study of the composition of guavas at different stages of ripeness, as well as a study of the method of manufacture in the cannery. This, so far, it has not been possible to do.

Samples of wattle bark (*Acacia decurrens*) were examined for percentage of tannin, and this found to vary from 29 to 35 per cent on the weight of the air-dried bark. These were samples of bark harvested and shipped from the station during the year. Two samples of koa bark (*Acacia koa*) were also examined for tannin content and found to contain 12.69 and 17.51 per cent. These samples were obtained from Hawaii.

The Hawaiian Fiber Company submitted samples of the waste wash water from the sisal cleaning machine, with the request that if possible some use be found for this material. This wash water is the juice of the sisal leaves, with the water added in cleaning the fiber. In this dilute condition the organic content is low, the ash rather high, and 70 per cent of the ash lime. From examination of the samples it did not seem likely that any better use could be made of the waste water than is now being made, viz, returning it to the land. The same company submitted samples of sisal waste, i. e., the short fibers from the butts of the leaves, with a request that its value for paper making be determined. Crude paper has been made from this material, but the determination of its value and the best method of treatment can be made satisfactorily only in a paper mill or a laboratory properly equipped for such work, which this laboratory is not.

Samples of granulated sugar (2), condensed milk (1), guano (3), and canned pineapple (1), of no special interest except to those asking for the analyses, were analyzed and reported on.

Miscellaneous work of this kind of course calls for correspondence. Some of this was obviated by the possibility of personal interview with inquirers. There has also been some correspondence where no samples were submitted. With the idea in mind that the dissemination of knowledge is not the chief work of an experiment station worker, the aim has been to keep correspondence in as subordinate a position as was consistent with the answering of reasonable inquiries. With slight encouragement this miscellaneous work and correspondence would increase so as to take the chemist's whole time. The chemical work at this station is free from many of the things which tend to retard special work. There is no teaching, no fertilizer, feeding stuff, nor food control; but miscellaneous consulting work spread over the whole field of chemistry is really more distracting to one trying to follow some special line than teaching or routine analyses, where the work is carried on along certain well-defined lines.

RESEARCH WORK.

The nature of the research work undertaken, an investigation of the nature of the nitrogenous compounds in Hawaiian soils, was briefly explained in the last report.

While in the temporary laboratory two matters supposed to be intimately connected with this subject were taken up chiefly because there were not at that time facilities for other work. These were soil acidity and denitrification. Acidity determinations, according to the method proposed by Hopkins, Knox, and Pettit,[a] were made on all the samples of soil on hand—twenty-five. Two only of these were acid to litmus when moistened with water, but all gave more or less acid solutions when extracted with 5 per cent salt solution. This acidity, when calculated to the equivalent amount of calcium carbonate, varied from 300 to 700 pounds for 1 acre of soil to the depth of 1 foot. How far this method is applicable to Hawaiian soils is yet to be determined, and efforts are being made to do this by field tests. The acidity shown by this method evidently does not interfere to any great extent with nitrification, for the samples examined contained nitrogen as nitrates varying from 15 to 55 parts per million. In determining the nitrate in these soils the method used was to add 500 cubic centimeters of water to 100 grams of soil, shake 3 minutes, let stand 20 minutes, filter, and determine nitrates in 100 cubic centimeters of the filtrate by the phenol-sulphonic acid method. It was found that in cases when the soil and water had been allowed to stand overnight (14 hours) the nitrate had much decreased, and in some cases disappeared altogether. This applied to all the soils examined, and occurred whenever the soil stood for some hours saturated with water. The following example will illustrate this:

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[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 73, p. 114.

		Parts per million.
No. 1.	100 grams of soil, 500 cubic centimeters water; shaken 3 minutes, let stand 20 minutes; nitrogen as nitrate	32.5
No. 2.	100 grams of soil, 500 cubic centimeters water; shaken 3 minutes, let stand 1 hour; nitrogen as nitrate	47.5
No. 3.	100 grams of soil, 500 cubic centimeters water, shaken 3 minutes, let stand 22 hours; nitrogen as nitrate	4.0
No. 4.	100 grams of soil, water to saturation (75 cubic centimeters) added, let stand 22 hours; 425 cubic centimeters water added, shaken 20 minutes; nitrogen as nitrate	4.0

With another sample of soil from the same place the time factor was determined roughly by saturating 100 grams with 75 cubic centimeters water and proceeding as above in No. 4, varying the time. The results were as follows:

	Parts per million.
Stood 2 hours; nitrogen as nitrate	40
Stood 4 hours; nitrogen as nitrate	40
Stood 6 hours; nitrogen as nitrate	40
Stood 8 hours; nitrogen as nitrate	40
Stood 10 hours; nitrogen as nitrate	40
Stood 12 hours; nitrogen as nitrate	15
Stood 13 hours; nitrogen as nitrate	4
Stood 14 hours; nitrogen as nitrate	4
Stood 15 hours; nitrogen as nitrate	4

Soil from another place, by treatment as above, gave the following figures:

	Parts per million.
Stood 1 hour; nitrogen as nitrate	35
Stood 12 hours; nitrogen as nitrate	30
Stood 16 hours; nitrogen as nitrate	25
Stood 20 hours; nitrogen as nitrate	11
Stood 24 hours; nitrogen as nitrate	11

The influence of varying amounts of water is shown roughly by the following figures. The soil treated contained 38 parts of nitrogen as nitrate per million and required 75 cubic centimeters to saturate it.

	Parts per million.
75 cubic centimeters water added, let stand 24 hours, nitrogen as nitrate	0.5
65 cubic centimeters water added, let stand 24 hours, nitrogen as nitrate	1.5
55 cubic centimeters water added, let stand 24 hours, nitrogen as nitrate	38.0
45 cubic centimeters water added, let stand 24 hours, nitrogen as nitrate	38.0

The addition of a small amount of chloroform to the soil, or heating after saturation with water to 125° C. for five minutes, prevented this change of nitrates in the case of all the soils examined.

As was to be expected, this denitrification took place equally as rapidly with nitrates added as with that naturally in the soil. In working on this phase of the question larger quantities of soil were used, usually 500 or 1,000 grams. A number of soils were studied from this standpoint, and in a number of different ways, but the statement of one case will probably be sufficient at present. One thousand grams of soil containing 15 parts of nitrogen as nitrate were placed in a glass percolator of such size that the soil was about 8 inches in depth, and after saturation with water was allowed to stand 24 hours. Three hundred cubic centimeters of water containing 1 gram of potassium nitrate was then added, the drainage caught, and the total nitrogen, nitrate, ammonia, and nitrites determined in aliquot portions. This was repeated, at intervals of 24 or 48 hours, until 1.42 grams of nitrogen as potassium nitrate had been added. The soil was then washed until the drainage was free from nitrate, the drainage being analyzed as before. The figures obtained were as follows:

	Grams.
Total nitrogen added as nitrate	1.42
Total nitrogen recovered in drainage	.56
Difference	.86

The total nitrogen recovered in the drainage was distributed as follows:

	Grams.
Recovered as nitrate	0.268
Recovered as ammonia	.257
Recovered as nitrite	.008
Recovered as other forms	.027

The difference between the amount of nitrogen added as nitrate, and the total nitrogen recovered, can be explained in one of two ways—either 0.86 gram of nitrogen as nitrate had been changed to free nitrogen and had escaped, or it had been fixed in the soil in some form difficultly soluble, probably organic. Opposed to the first explanation is the fact that at no time while the soil was standing, or on the addition of the nitrate solution, was any evolution of gas observed, and as 0.86 gram of moist nitrogen measure 792.6 cubic centimeters at 30° C and 760 millimeters, it is not conceivable that even a small portion of this amount could escape as gas without detection. In support of the second explanation is the nitrogen content of the soil. The original soil contained nitrogen 0.987 per cent and moisture 16.65 per cent, which is equivalent to 1.184 per cent nitrogen in the moisture-free soil. The figures obtained from the wet soil in the percolator after treatment were nitrogen 0.64 per cent and moisture 49.30 per cent, which is equivalent to nitrogen in the moisture-free soil 1.262 per cent. The difference obtained from analyses of the soil 0.78 per cent nitrogen is reasonably near the difference between nitrogen added and nitrogen recovered, viz, 0.86 gram in 1,000 grams of soil or 0.086 per cent.

There is, of course, nothing new in the recognition of the phenomenon of denitrification. It has been generally recognized as taking place in soils, especially those rich in organic matter, when for any reason there was not free access of air, as in the presence of excess of water. Various substances such as fresh manure, straw, etc., have been stated as being important factors in the case. Several investigators have also pointed out that in some cases there are good grounds for the assumption that in this change of nitrates a portion is stored in the soil in a little soluble, probably organic form.

Most writers on the subject make the statement that under ordinary conditions of cultivation denitrification is not an important factor in the growing of crops. While this may be true, generally, there are certain phases of the situation in Hawaii, notably climatic conditions and irrigation practices, which, in view of the preliminary work outlined above, force the conclusion that it is an important question here. In most localities here where crops are grown depending on the rainfall alone, there are times when the soil is practically saturated with water for weeks at a time. Where irrigation is practiced, limited for the most part to cane growing, it has been shown by several workers here that the soil is practically at or near the saturation point throughout the irrigating season; conditions which, as shown, bring about the denitrification of nitrate present or added to the soil. It has for a long time been accepted as axiomatic, especially by the planters here, that heavy rains or excessive amounts of irrigation water wash all nitrates out of the soil unchanged. This the work outlined above has demonstrated to be a mistake. For instance, in the experiment with 1,000 grams of soil noted above, the amount of nitrate added was equivalent to 15 tons of nitrate of potash per acre, using the weight of soil to the depth of 8 inches as the basis of calculation. But after the addition of this excessive amount of nitrate, when the soil was washed continuously for about one month until no nitrate was contained in the drainage, only 18 per cent of the nitrate added was recovered.

While the samples of soil examined in this work have not been numerous, extreme types have been included from different islands, and the data obtained are sufficient to warrant the assertion that a widespread characteristic of Hawaiian soils is that when they are at or near the saturation point with respect to water, there is a change of nitrates and an apparent fixation of a portion of the nitric nitrogen in a form not easily soluble.

In this connection the question naturally arises: If a portion of the nitric nitrogen is fixed in the soil, in what form is it; and is it, or does it become, available for plant growth? A study of this question and a further study of the factors influencing the change will be carried on during the coming year.

On the completion of the new laboratory work was resumed on the study of the constitution of the nitrogenous compounds in Hawaiian soils. The considerations which led to taking up this work have been stated in the last report. It was decided to work on a soil or soils, fairly high in nitrogen, for the obvious reason that smaller quantities of soil would have to be handled to obtain amounts of nitrogenous bodies sufficient for identification; and also for the reason that the majority of soils, especially on Hawaii, suitable or available for crops other than cane are of this nature.

The work done has, for the most part, been on soil from one locality, viz, Pohakea, Hawaii, where this station is experimenting with tobacco. Along certain lines the work has been carried on with other soils, but the data from these is as yet fragmentary, and the results given below apply to the single soil mentioned above. Mechanical and partial chemical analyses of this soil have been published in Press Bulletin No. 12 of this station and are as follows:

Analysis of Pohakea soil.

Mechanical analysis, soil dried at 100° C.	Per cent.	Chemical analysis.	Per cent.
Combined water and organic	35.935	Water	19.540
Fine gravel 1-2 mm	16.511	Organic and combined water	28.360
Coarse sand 1-0.5 mm	11.337	Insoluble	19.320
Medium sand 0.5-0.25 mm	6.716	Fe_2O_3 Al_2O_3 iron and alumina	28.797
Fine sand 0.25-0.1 mm	14.002		
Very fine sand 0.1-0.05 mm	8.339	CaO lime	.300
Silt 0.05-0.0005 mm	5.848	MgO magnesia	.631
Clay 0.005-0.0001 mm	.940	SO_3 sulphuric acid	.343
		P_2O_5 phosphoric acid	.703
		K_2O potash	.077
		Nitrogen total	.728
		Humus total	12.470
		Humic nitrogen	.560
		Nitrogen in humus	4.490

The chemical analysis was made by the official method on soil which had passed a 0.5-millimeter sieve.

The work outlined below, however, was all done with soil which had passed a 1-millimeter sieve, the nitrogen content of which was higher, viz. 0.868 per cent. Nitrogen determinations were made by the Gunning method, without modification to include nitrates, and it is assumed that the small amount of nitrate present, 15 to 20 parts per million, does not enter as a factor at all. Throughout, percentage of nitrogen is calculated on the basis of air-dried soil, e. g., in the first example given below, total nitrogen in drainage 0.005 per cent means 0.005 gram of nitrogen from 100 grams of soil.

Despite the relatively large amount of nitrogen present, its extremely insoluble condition is shown by the following figures:

1. 1,000 grams of soil placed in a glass percolator; washed with 6,000 cubic centimeters water in portions of 200 cubic centimeters. Total nitrogen in drainage, 0.005 per cent.
2. 10 grams of soil boiled with 100 cubic centimeters water 1 hour, filtered and washed to 500 cubic centimeters. Total nitrogen in filtrate, 0.022 per cent.
3. 10 grams of soil treated in the cold with 100 cubic centimeters of 12 per cent hydrochloric acid, for 1 hour, filtered and washed with 200 cubic centimeters acid, and then with water to 500 cubic centimeters. Total nitrogen in filtrate, 0.002 per cent.
4. The residue from the treatment above was heated for 1 hour with 100 cubic centimeters water at 125° C.; filtered and washed to 500 cubic centimeters. Total nitrogen in filtrate, 0.042 per cent.
5. 10 grams of soil shaken for 2 hours with 100 cubic centimeters 95 per cent alcohol, washed with 200 cubic centimeters alcohol. Total nitrogen in filtrate, none.
6. 10 grams of soil shaken for 2 hours with 100 cubic centimeters 10 per cent salt solution, filtered, and washed free of chlorids. Total nitrogen in filtrate, 0.006 per cent.
7. 10 grams of soil heated for 3 hours with 100 cubic centimeters water at 125° C., filtered, and washed to 500 cubic centimeters. Total nitrogen in filtrate, 0.050 per cent.

Hot acids and alkalis had a pronounced solvent action, as shown by the following figures:

1. 10 grams of soil boiled for 7 hours under a reflux condenser with 100 cubic centimeters of 12 per cent hydrochloric acid, filtered, and washed free from acid. Total nitrogen in filtrate, 0.623 per cent.
2. The insoluble portion from the above treatment was digested (boiled) for 5 hours with 100 cubic centimeters of 12 per cent sulphuric acid, filtered, and washed free from acid. Total nitrogen in filtrate, 0.112 per cent, leaving 0.133 per cent insoluble after two digestions with acid.
3. 5 grams of soil were digested with 100 cubic centimeters of water and 10 cubic centimeters saturated solution cf caustic potash for 1 hour, filtered and washed. Total nitrogen in filtrate, 0.728 per cent.

After these preliminary tests of solubility and behavior with reagents the following somewhat hit or miss experiments were made with the hope of having some light thrown on probable constitution of the nitrogenous bodies present:

1. 10 grams of soil were digested with 100 cubic centimeters of acid pepsin for 12 hours at 40° C., filtered and washed. Total nitrogen dissolved, 0.076 per cent.
2. 5 grams of soil treated with cupric hydrate according to the official method for albuminoid nitrogen gave total nitrogen insoluble 0.851, or 0.011 per cent soluble.
3. 10 grams of soil boiled for 30 minutes with 2 grams of permanganate of potash and 125 cubic centimeters water; filtered and washed. Total nitrogen insoluble, 0.352 per cent, or 0.516 per cent soluble in neutral permanganate.

About the only positive information obtained from the above was the fact that a portion of the insoluble nitrogen could be oxidized to a soluble form by neutral permanganate. By repeating the digestion with an excess of permanganate the amount remaining insoluble was 0.229, or 0.539 per cent soluble.

By the combined action of permanganate and alkali a considerable portion of the nitrogen was set free as ammonia, e. g., 5 grams of soil on distillation with 1.6 grams permanganate, 1.5 grams caustic soda and 100 cubic centimeters water, gave nitrogen as ammonia 0.162 per cent, and on repeating the distillation as above with 10 grams permanganate, the nitrogen set free as ammonia was 0.308 per cent.

That in the first case above the nitrogen set free as ammonia, viz, 0.162 per cent, was due chiefly to the action of the alkali was shown as follows: 5 grams of soil on distillation with 1.5 grams caustic soda and 100 cubic centimeters water gave nitrogen set free as ammonia 0.154 per cent.

The amount of nitrogen present in the soil as ammonia determined by distillation with excess of magnesia was found to be 0.007 per cent. By using excess of milk of lime instead of magnesia distilling in a current of steam gave nitrogen as ammonia 0.035 per cent and distillation by direct heat 0.053 per cent.

The ready solubility of portion of the nitrogen in boiling acids seemed to promise some information, and solutions so obtained were treated by the method proposed by Osborne and Harris.[a] By this method, which in its turn is a modification of a method proposed by Hausmann,[b] the decomposition products which result from boiling protein bodies with acids are classified. The method, briefly, is freeing the solution from excess of acid by evaporation; determination of the nitrogen present as ammonia by distillation with magnesia; filtering from the magnesia precipitate; determination of the nitrogen in the magnesia precipitate, the basic nitrogen in the filtrate by precipitation with phosphotungstic acid, and the nonbasic nitrogen by difference.

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[a] Jour. Amer. Chem. Soc., 22 (1905), p. 323.

[b] Ztschr. Physiol. Chem., 27, p. 92.

In the application of this method to soils 12 per cent acid was used instead of 20 per cent, as used by Osborne and Harris.

As stated above, boiling 10 grams of soil with 100 cubic centimeters of 12 per cent hydrochloric acid for seven hours gave 0.623 per cent nitrogen in solution; and treatment of the insoluble residue for five hours with 100 cubic centimeters 12 per cent sulphuric acid gave further soluble nitrogen 0.112 per cent. Treatment of the solutions so obtained by the method stated gave the following figures:

Forms of nitrogen in acid extracts.

	Per cent.
Hydrochloric acid solution:	
Nitrogen as ammonia	0.119
Nitrogen in magnesia precipitate	.280
Basic nitrogen	.140
Nonbasic nitrogen	.084
Total nitrogen in solution	.623
Sulphuric acid solution:	
Nitrogen as ammonia	None.
Nitrogen in magnesia precipitate	.105
Basic nitrogen	.005
Nonbasic nitrogen	.002
Total nitrogen in solution	.112

In comparing these figures with those obtained by Osborne and Harris working on pure protein bodies, the most striking point is the large amount of nitrogen contained in the magnesia precipitate. In the case of protein bodies it does not exceed 4 per cent of the total nitrogen and in most cases is very much less; but in the soil solutions it amounts to 45.2 per cent of the total in the hydrochloric acid solution and 93.7 per cent of total in sulphuric acid solution. Taking both solutions, we have total nitrogen in solution 0.735 per cent; nitrogen in magnesia precipitate 0.385 per cent, or 52.3 per cent of total.

This method has been applied to a number of soils with the same general result. It has also been found that increasing the time of boiling above two hours gave but slight increase in the amount of nitrogen dissolved. For example, in one case the difference between two hours and fourteen hours was 0.080 per cent, and the amount of nitrogen in the magnesia precipitate was in each case practically the same.

It seems a legitimate conclusion from this work that in the soil nitrogen which is soluble in boiling acids a portion, approximately 50 per cent, is in a form unlike, for the most part, the products of decomposition of protein bodies with acids.

Practically the same result has been obtained by using barium hydrate instead of magnesia. In a method proposed by Kossel and

Kutscher[a] for the separation of certain bodies resulting from the decomposition of protein with acids barium hydrate is used in this way. The amounts of nitrogen in the barium precipitate by this method when working on protein bodies is small, and the authors speak of it as humus nitrogen. Considering the small amounts involved and the fact that the method was applied in the study of other bodies, the authors are probably justified in using this vague term. In the case of a soil solution, however, containing 50 per cent of so-called humus nitrogen, such designation is very unsatisfactory since it conveys little or no information as to the nature of the body or bodies so named.

Along this line, then, a study of the nature of the nitrogen compound or compounds contained in the magnesia precipitate from acid solutions is the present stage of the work.

Approaching the nitrogen problem from another standpoint, some work has been done which may be outlined as follows:

All Hawaiian soils rich in nitrogen which have so far been examined give on dry distillation an alkaline distillate containing ammonia. In many cases the smell of ammonia on simple ignition in an open crucible is very pronounced.

The alkalinity of this distillate has been determined in a number of cases. The distillation was carried on first at a gentle heat and finally raised to a red heat, the distillate being collected in a known volume of standard acid. In the case of the Pohakea soil, assuming the alkalinity to be due to ammonia, it was found to be equivalent to 0.168 per cent nitrogen. The total nitrogen in the distillate was 0.145 per cent. It is interesting at this point to compare the ammonia actually in the soil as found by distillation with magnesia, 0.007 per cent, and also the ammonia derived from the acid solution, 0.119 per cent.

In addition to ammonia this distillate contains pyridin and some of its homologues not yet identified. The proportion of the alkalinity due to ammonia and that due to the pyridins has of course not yet been determined.

Generally speaking, pyridin is formed on the dry distillation of nitrogenous carbon compounds and as derived in this way is found in coal tar, tar from shales, peat, and in bone oil. Richter[b] says: "Its presence in bone oil is due to the reciprocal action of fats and substances containing ammonia (albumins), the acrolein arising from the first probably condensing with the ammonia to form pyridins. Bone glue free from fats does not yield pyridin bases, but mainly pyrrols."

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[a] Ztschr. Physiol. Chem., 30 (1900), p. 166.

[b] Organic Chemistry, vol. 11, p. 528.

As the fat in this soil was found to be only 0.005 per cent, it does not seem likely that the pyridin formed was due to the formation of the pyridin ring by condensation, but rather that it exists already in some form in the soil.

Having in mind the light which has been thrown on the constitution of complex pyridin compounds by oxidation processes, oxidation of the soil by neutral and alkaline permanganate has been tried, and, while no very definite results have been obtained, enough has been accomplished to warrant continuing the work along this line. The action of alkaline permanganate on these soils is very energetic, and large containers are necessary to operate on quite small quantities of soil without loss.

The operation as carried on, without detailing unimportant variations, has been as follows: Permanganate, in small quantities at a time, was added to the soil suspended in water or alkaline solution, gentle heat being applied. When the addition of permanganate produced no further action, the manganese dioxid was filtered off, the filtrate neutralized with nitric acid, filtered, and the filtrate treated in various ways to recover oxidation products. This solution gives precipitates with lead, mercury, and silver salts, with cupric acetate in the cold and a further precipitate on heating. When the permanganate had been strongly alkaline there was obtained by decomposition of these precipitates with hydrogen sulphid a residue mostly crystalline, consisting for the most part of oxalic acid. By fractional crystallization and treatment with different solvents there has been obtained from this residue small quantities of a crystalline body giving pyridin on ignition with lime and the red color with ferrous sulphate characteristic of several of the pyridin carboxylic acids. The production of a relatively large amount of oxalic acid by the oxidation of the carbonaceous matter in the soil by the action of the permanganate is a serious obstacle in working along this line.

When the oxidation is carried on with neutral permanganate, or when the process in alkaline solution is not carried to completion, there was obtained by the same procedure a dark red or brown, apparently amorphous body, which gave pyridin on ignition with lime. This, apparently, is the body from which on further oxidation the pyridin carboxylic acid is formed.

At this stage this line of the work stands at present.

FUTURE WORK.

Throughout the foregoing report enough work has been outlined for some time to come. The fodder analyses and research work will be carried on along the lines indicated.

Miscellaneous work will probably continue to come in, but the only thing of this nature in view at present is the determination of the value of bananas and pineapple waste for the production of alcohol. Banana growers, especially on Hawaii, have had difficulty in securing proper transportation for their bananas, and at all times have some small or inferior bunches which are not salable. It has been thought that it might be profitable to utilize such inferior fruit, or fruit which could not be shipped, in the manufacture of alcohol.

In the canning of pineapples there is a large amount of waste, peelings and cores amounting to about 40 per cent of the weight of the fruit. At present no use is made of this waste, and it seems too large in amount not to be of some value.

REPORT OF THE ENTOMOLOGIST.

By D. L. Van Dine.

INTRODUCTION.

Necessary additions have been made during the year to the office furniture and laboratory equipment. The records of the office are kept on card indexes, according to modern systems on the mainland, but modified to meet the requirements of one working without clerical or other assistance. Many additions have been made to the entomological library, a catalogue of which has been prepared. The correspondence continues to occupy a considerable portion of the time of the entomologist, but much time is being saved by his being able to place some of the information requested into the hands of the correspondents through the various entomological publications of the station.

Acknowledgment is made for many courtesies from other workers, and especially for the direct assistance given in the determination of specimens and for other information by Dr. L. O. Howard and other experts of the Bureau of Entomology of the U. S. Department of Agriculture.

ENTOMOLOGICAL ORGANIZATIONS IN HAWAII.

The past year has been an important one in the history of the economic entomology of the Hawaiian Islands. During this interval the Territorial government has organized and equipped a division of entomology, under the newly formed board of commissioners of agriculture and forestry, for quarantine and inspection and the introduction of the parasitic and predaceous enemies of insect pests. This department of the Territorial board supplants the office of the Territorial entomologist created by the provisional government of the Hawaiian Islands under the commissioner of agriculture and forestry in 1893, to which office Mr. Albert Koebele was appointed. On May 18, 1903, immediately after the formation of the newly appointed board of commissioners, Mr. Koebele was made superintendent of the division of entomology, with Mr. R. C. L. Perkins as assistant superintendent and Messrs. G. W. Kirkaldy and F. W. Terry as assistants.

During the summer of 1904 the Hawaiian Sugar Planters' Association organized on a still more elaborate scale a division of entomology in their experiment station, Mr. R. C. L. Perkins resigning from the Territorial department to become director of the division of entomology in the Sugar Planters' station, with Messrs. Kirkaldy and Terry as assistants. Mr. Koebele, because of his special duties in the collection and introduction of the parasitic and predaceous enemies of injurious insects from abroad, also resigned as superintendent of the Territorial division of entomology. The board of commissioners of agriculture and forestry appointed Mr. Alexander Craw, formerly deputy commissioner of horticulture of California and State quarantine officer, as superintendent of entomology, with Mr. Koebele as consulting entomologist. Messrs. Koebele and Craw, are also consulting entomologists of the Sugar Planters' experiment station. The Sugar Planters' Association further appointed Mr. Otto H. Swezey as assistant entomologist. The board of commissioners of agriculture and forestry, to complete their staff, appointed Mr. Jacob Kotinsky as assistant entomologist, Mr. C. J. Austin, inspector's assistant, and the following "honorary entomological inspectors" for the principal ports of the islands outside of Honolulu: Mr. E. A. Frasier, Mahukona, island of Hawaii; Mr. J. Castle Ridgeway, Hilo, island of Hawaii; Mr. W. O. Aiken, Kahului, island of Maui; and Mr. W. D. McBryde, Koloa, island of Kauai.

The present official entomological organizations in Hawaii in the order of their creation are:

Department of Entomology, Hawaii Agricultural Experiment Station, under the supervision of the Office of Experiment Stations, U. S. Department of Agriculture, Honolulu, Hawaii.

Organized July 1, 1902. Lines of work: Collection and study of the insect pests of Hawaii in their relation to the agricultural development of the Territory and the publication of information on the life history, development, habits, and injury, with the known cultural, natural, and active remedies applicable for their control.

Staff: D. L. Van Dine, entomologist.

Division of Entomology, Board of Commissioners of Agriculture and Forestry of the Territory of Hawaii, Honolulu, Hawaii.

Organized May 18, 1903. Lines of work: "All matters relating to the exclusion or eradication of insects, scales, blights, and diseases injurious, or liable to become injurious, to trees, plants, or other vegetation of value, and relating to the quarantine, inspection, disinfection, exclusion or destruction of any plant, article, or substance injurious, or liable to become injurious, to trees, plants, or other vegetation of value mentioned in or coming within the scope of this act, and of such other matters as the board may from time to time direct."

Staff: Alexander Craw, superintendent and inspector.
A. Koebele, consulting entomologist.
Jacob Kotinsky, assistant entomologist.
C. J. Austin, inspector's assistant.

Division of Entomology, Experiment Station of the Hawaiian Sugar Planters' Association, Honolulu, Hawaii.

Organized August, 1904. Lines of work: Study of the insect pests of sugar cane, and the collection, introduction, and distribution of the parasitic and predaceous enemies of the insect pests of sugar cane.

Staff: R. C. L. Perkins, director.
A. Koebele, consulting entomologist.
Alexander Craw, consulting entomologist.
G. W. Kirkaldy, assistant entomologist.
F. W. Terry, assistant entomologist.
Otto H. Swezey, assistant entomologist.

BEE KEEPING.

The bee keeping industry in the Hawaiian Islands represents an investment of approximately $150,000. With the exception of a few Japanese who are engaged in the work individually on a small scale and certain others who produce comb honey for local consumption, the industry is in the hands of three corporations, one of which equals in production the combined product of the other two. It is apparent that with the completion of the plans of expansion now under way by these corporations the next year or so will see the various honey producing localities of the islands well covered and the limit of production attained. (Pl. II, figs. 1 and 2.) This is of course on the present basis of production. The entomologist believes that the local consumption of this product could be greatly increased and in the local market a small producer could easily compete with a large corporation where the freight rates and amount produced would not permit competition in the markets of the mainland or Europe. Again, many small producers could organize an association and grade and market their honey in bulk with equal advantage in comparison to large shipments of a single concern. Although under corporation management the honey industry will in the near future reach its limit, there is still room under proper management for small producers, depending only in part on honey for their income and perhaps doing a large share of the manipulation of the apiary at odd hours of their time, to enter the field and obtain a fair return for their labor. As with silk culture, bee keeping could be carried on in certain localities as a side issue and, by organizing the marketing, prove a source of income.

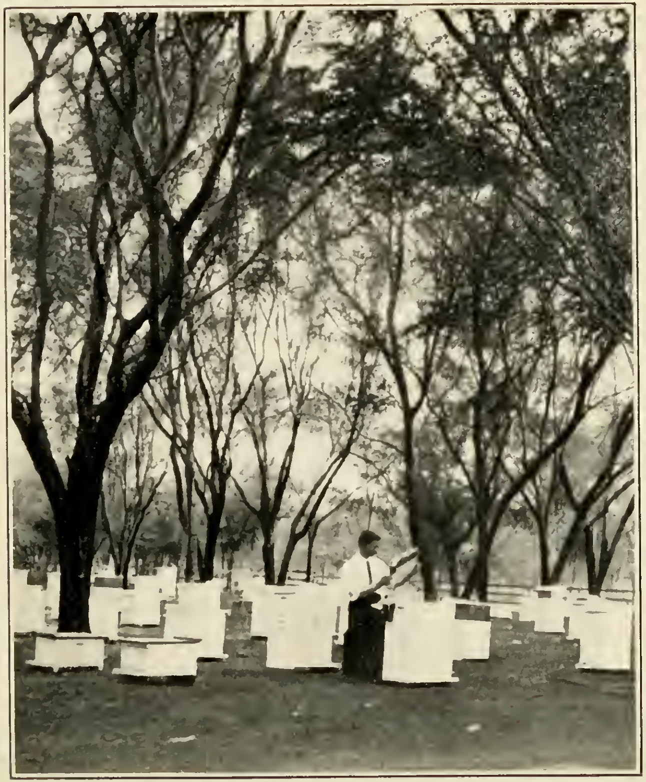

FIG. 1.—APIARY AT PEARL CITY, OAHU, UNDER ALGEROBA TREES.

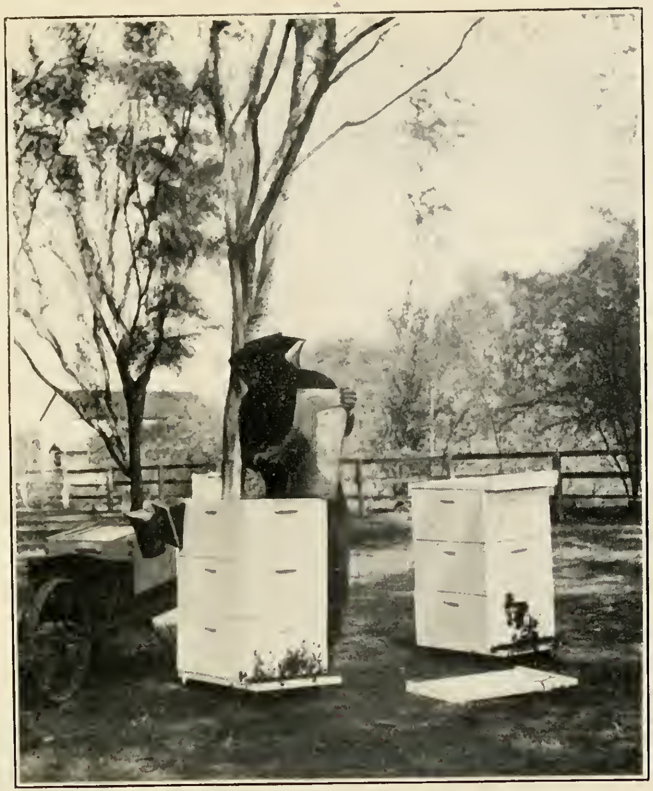

FIG. 2—JAPANESE HELPER ROBBING HIVES.

PARTIAL LIST OF HONEY-PRODUCING PLANTS OF HAWAII.

Algeroba, native "keawe." *Prosopis juliflora.* This tree is the most abundant and principal bee plant of the islands, and the principal apiaries are situated along the coast of the various islands in the shelter of the algeroba forests.

Various species of Acacia—wattle, koa, etc.

Sisal (*Agave sisalana*).

Alligator pear (*Persea gratissima*).

Banana (*Musa* spp.).

Various species of Eucalyptus.

Guava (*Psidium* spp.).

Lantana.

Various species of Citrus—orange, lemon, lime, etc.

Loquat (*Eriobotrya japonica*).

Various species of cucurbits.

Rose apple (*Eugenia jambos*).

Sugar cane (*Saccharum officinarum*).

Tamarind (*Tamarindus indica*).

Tobacco (*Nicotiana tabacum*).

Catalpa speciosa, a good honey tree introduced some three years ago by Mr. Jared G. Smith, special agent in charge of this station.

Ilima (*Sida cordifolia*).

Palms.

This station has successfully introduced the Italian bee into the Philippines during the past year and will undertake to import certain bees into these islands during 1906.

SILK CULTURE.

The production of raw silk is essentially a "home" occupation—a work for women and children, and men at idle seasons of the year. The labor requires a certain amount of training, but only such as is easily acquired by a season's work or so. It would seem that this industry is well suited to the conditions in these islands. The climate in some localities is even and cool, the mulberry thrives over the entire group of islands, and in the large families of Japanese and Portuguese we have people who could increase the income of the family and at the same time add to the revenue of the country. The cultivation of silkworms by the families of plantation laborers on lands above the cane would lead to more stable labor conditions and attach the laborers more closely to the country. It is an industry likewise that might well be considered in conjunction with coffee growing. It will evidently be most desirable to import the eggs from California, and the work, if undertaken, should be so organized in the various communities that some one person is responsible for the introduction of the eggs in cold storage and their artificial incubation, since the warmer temperature of these islands will not permit normal hatchings under natural conditions.

Two breeding experiments have been conducted at the station, one under natural conditions and the other with eggs imported in cold storage and kept on ice until ready for hatching. The results of these experiments are given in the following tables and illustrate in the first instance the variability of hatching and development under natural conditions and in the second experiment more encouraging results under artificial conditions.

The introduction of the eggs and their hatching by some one person understanding their proper manipulation and having the distribution of the worms to the individual growers would prevent a repetition of the failure several persons have met with who have sought to establish the industry in Hawaii. After further work a more careful and detailed consideration of the question will be published by this station.

In the first table the silkworm eggs were received by mail from Tokyo, Japan, whence they were forwarded December 12, 1904. In the second table the eggs were forwarded from Washington, D. C., in cold storage March 6, 1905, and removed from the ice April 1, 1905.

Variable hatching and development of silkworm eggs shipped under normal conditions.

Date of hatching.	Molting periods.				Beginning of spinning.	Total life period.
	First.	Second.	Third.	Fourth.		
						Days.
Jan. 1	Jan. 7	Jan. 8	Jan. 26	Feb. 2	Feb. 12	42
Jan. 2–5	Jan. 14	Jan. 20	Jan. 27	Feb. 3	Feb. 13	39
Jan. 6–9	Jan. 18	Jan. 23	Jan. 31	Feb. 7	Feb. 16	38
Jan. 10–12	...do...	Jan. 26	Feb. 3	Feb. 10	Feb. 19	38
Jan. 13–16	Jan. 20	Jan. 27	Feb. 7	Feb. 13	Feb. 22	37
Jan. 17–20	Jan. 24	Jan. 31	Feb. 9	Feb. 16	Feb. 25	36

On January 23 the eggs were hatching very slowly, and fully one-third were thrown away. The mean maximum temperature from January 1 to February 25 was 78.9° and the minimum 62.7° F. The sky was almost uniformly clear during the whole time.

Uniform hatching and development of silkworm eggs shipped in cold storage.

Date of hatching.	Molting periods.				Beginning of spinning.	Total life period.	Weight of cocoons.
	First.	Second.	Third.	Fourth.			
						Days.	*Lbs. ozs.*
Apr. 2	Apr. 7	Apr. 13	Apr. 19	Apr. 26	May 6	34	10 3
Apr. 3	Apr. 8	Apr. 14	Apr. 20	Apr. 28	May 7	34	14 10
Apr. 4	Apr. 9	Apr. 15	Apr. 21	Apr. 29	May 9	35	12 15

The mean maximum temperature during the growing period was 78.84° and the minimum was 66° F. The weather was partly cloudy most of the time. The silkworms were killed with fumes of carbon bisulphid, and the weight of the cocoons after drying until August 1 was 18 pounds 6 ounces.

The times of feeding and weight of mulberry leaves consumed are shown in the accompanying table:

Time of feeding and food consumed by silkworms hatched from one-third ounce of eggs.

Time of feeding.	Times fed per day.	Amount consumed in 24 hours.	
		Lbs.	*ozs.*
Apr. 2	7	0	2
Apr. 3	7	0	5
Apr. 4	7	0	8
Apr. 5	7	0	15
Apr. 6	7	0	9
Apr. 7	7	1	6
Apr. 8	7	1	2
Apr. 9	7	1	5
Apr. 10	7	2	1
Apr. 11	7	4	0
Apr. 12	7	6	8
Apr. 13	7	5	6
Apr. 14	7	4	8
Apr. 15	6	3	0
Apr. 16	6	6	4
Apr. 17	6	9	8
Apr. 18	6	11	0
Apr. 19	6	11	8
Apr. 20	6	8	0
Apr. 21	6	6	0
Apr. 22	6	13	0
Apr. 23	6	20	0
Apr. 24	6	29	0
Apr. 25	6	26	0
Apr. 26	6	25	0
Apr. 27	6	17	8
Apr. 28	6	15	0
Apr. 29	6	22	0
Apr. 30	6	28	0
May 1	5	47	0
May 2	5	51	0
May 3	5	53	0
May 4	5	63	0
May 5	5	60	0
May 6	5	58	0
May 7	5	43	0
May 8	5	22	8
May 9	5	15	8
May 10	5	7	8
May 11	5	1	8
Total		707	10

MOSQUITOES.

Active work in mosquito control on the part of the Citizens' Mosquito Committee ceased last year, and the subject was turned over to the Territorial board of health. An item of $7,200 to conduct the campaign was proposed for the regular appropriation bill of the board of health for two years, but this did not receive the indorsement of the administration, and the board has relied on money from private sources to defray the expenses of the work. It has been demonstrated thoroughly that it is possible to control the nuisance, and constant headway is being made in bringing householders to a realization of their responsibility in the matter of the mosquitoes infesting their houses. The citizens' committee found it impossible to continue the campaign on the basis of private subscriptions, since a few were paying for a benefit to all, and it was generally thought that since the demonstration had proved successful, the work should become a function of the government.

In the question of breeding places, there are many natural ones existent about taro patches, rice fields, and irrigation ditches that can not, without great expense, be treated directly. These places are not responsible for any large percentage of the mosquitoes in the towns and cities. However, places situated near by do receive their mosquitoes from these sources and they call for attention. It is proposed to stock these places with certain mosquito-eating fish. Aside from a few gobies, locally known as "oopu," the gold fish are the only fish in Hawaii that are especially fond of the mosquito wriggler. An attempt will be made to introduce into the islands fish that are special mosquito feeders.

INTRODUCTION OF MOSQUITO-EATING FISH.

Several years ago the entomologist concluded that the absence of special mosquito-feeding fish was responsible for the numbers of mosquitoes which must be credited as breeding in taro patches, rice fields, irrigation ditches, lily ponds, and especially the abandoned rice and taro fields. The following letter, self-explanatory, was addressed to Doctor Jordan:

January 9, 1903.

Dr. David Starr Jordan,
President Leland Stanford, jr., University,
Stanford University, Cal.

My Dear Doctor Jordan: I am working just now on the mosquito problem here. In regard to the natural enemies of this pest, I would like to find out what fish or fishes we have here in the small ponds, streams, taro patches, and rice fields (the natural breeding places of the mosquito) which feed to any extent on the larvæ and pupæ. The common "gold fish" occurs here in large numbers, and, I believe, feeds to a great extent on the young mosquitoes. I have observed a single fish eat nearly two hundred larvæ during two days' confinement in an aquarium. Other gold fish taken from small pools contained the remains of larvæ in their stomachs.

Doctor Howard speaks of the common sunfish and one or two species of "top minnows" as especially active in the destruction of mosquito larvæ and pupæ. Would it not be feasible for us to attempt to introduce some of these beneficial species to breed in places where it is undesirable to drain or use the oil treatment?

Very sincerely, yours,

D. L. Van Dine.

Doctor Jordan replied as follows:

Stanford University, Cal., *January 21, 1903.*

Mr. D. L. Van Dine,
Experiment Station, Honolulu, Hawaii.

Dear Sir: The only fishes that you have which feed upon mosquitoes in the small ponds are the different kinds of gobies, locally known as "oopu," and the gold fish. The different species of oopu are found in all the streams, but whether they feed on the larvæ or not must be determined by dissection.

The top minnows are entirely unrepresented in Hawaii. They are very easily transported, being extremely hardy. There are, however, none of them in California, and they would have to be brought either from the Mississippi Valley or from Mexico. The best species for your purpose could be found in the streams of central Mexico, but it would be a little costly to send a man down to get them. Next to these I would recommend trying the Gulf States or Florida. These species belong to the family of Pœciliidæ, and there are many species, nearly all American. The single Japanese species is common in rice ditches in the extreme south of Japan, and probably feeds on larvæ.

Very truly, yours,

David S. Jordan.

While Doctor Jordan was in Honolulu recently the subject was further discussed, and he offered to send an expert of Stanford University to the southern United States to collect representatives of the family of top minnows and introduce them into Hawaii, providing the Territory would furnish the money for the expenses of the trip. The proposal was submitted to the consideration of the governor by Dr. C. B. Cooper, as chairman of the legislative committee of the Citizens' Mosquito Committee, and the writer, as chairman of the advisory committee. This action led to the following communication to the governor on the subject:

HONOLULU, HAWAII, *March 12, 1905.*

HON. GEORGE R. CARTER,
Governor of the Territory of Hawaii, Honolulu.

SIR: Dr. David Starr Jordan, of Stanford University, having offered to send an expert of that institution to collect for these islands certain fish of the Southern States and Mexico, at present entirely unrepresented here, that feed upon the larvæ of mosquitoes, providing the Territory pay the expenses of such trip, the undersigned, at your request, beg to say that for the expense of such a trip a sum of not less than $1,500 should be provided. We suggest that, if appropriated for the above purpose, this sum, or as much thereof as is necessary, be spent under the direction of the board of health, since the president of that department of the government is the chairman of the Citizens' Mosquito Committee.

Very respectfully, yours

CHAS. B. COOPER, M. D.,
Chairman Legislative Committee.
D. L. VAN DINE,
Chairman Advisory Committee.
Representing the Citizens' Mosquito Committee of Honolulu.

At the opportune time this communication was transmitted to the legislature with the following indorsement:

(Letter of May 10, 1905, from Governor Carter to the legislature.)

To the Legislature of the Territory of Hawaii:

Herewith, I transmit for your consideration copy of a letter of March 12, containing a proposal made by Dr. David Starr Jordan, of Stanford University, to provide an expert, with the necessary apparatus, to undertake the importation into these islands of a certain small and vigorous fish found in Mexico that feeds on the larvæ of the mosquito, provided the Territory simply pays the expense of such an undertaking.

You are aware that the only fish we have at present exclusively occupying our fresh waters is a species of mud fish, commonly known as the oopu, and the gold fish. You are also aware that there is known to exist here the species of mosquito which carries the germs of yellow fever, which, fortunately for us, has not as yet been inoculated, but with the completion of the Panama Canal it will only be a question of time before cases of this or some other disease will reach this port. Every interest in the Territory would be advanced if this mosquito could in some way be entirely eradicated, or at least reduced to the smallest possible number.

G. R. CARTER, *Governor.*

The subject was referred to the health committee of the house at once, and the writer went before this committee and laid the question fully before them. The committee report favorably, and the item

($1,500) was included under general expenses of the Territorial board of health, and reads, "Expenses, importation of fish for destruction of mosquitoes, $1,500."

In accordance with the following letter, Doctor Jordan selected Mr. Alvin Seale to undertake this work:

Stanford University, Cal., *April 18, 1905.*

Mr. D. L. Van Dine,
United States Experiment Station, Honolulu, Hawaii.

Dear Sir: The best place to collect the fishes which you want would doubtless be in Louisiana. It would probably take no longer time to bring them from there than from other places nearer. Perhaps an equally good place would be Tampico, on the edge of Mexico. You understand that this would necessarily be an experiment. These little fishes feed freely on mosquitoes. Some live in brackish water, some in fresh water, and all of them are very hardy. But no one has ever yet tried to transplant any of them, and the whole thing might turn out, for some reason or other, to be a failure. Especially one would need to experiment on feeding the little fishes during their transportation. The genera which I would recommend are Mollienesia, Adinia, Gambusia, and Fundulus. Some of these are viviparous, others lay eggs. Whoever undertakes this should give a good deal of attention to the question of feeding the little fishes, and for this purpose perhaps a tank breeding mosquitoes would be as good as anything. The best time to undertake it would be about the 1st of June. I will select some one as soon as I hear from you.

Very truly, yours, David S. Jordan.

A PARTIAL LIST OF THE INJURIOUS INSECTS OF HAWAII, PART 2.

(Continued from Report of the Office of Experiment Stations, 1904.)

CITRUS TREES.

On October 27, 1904, citrus twigs were collected by J. E. Higgins, Mountainview, Island of Hawaii, infested with purple scale (*Lepidosaphes beckii* Newm.). The scales were infected with a fungus disease reported to be *Microcera rectispora* Che. and Mass. by Mr. A. F. Woods, of the Bureau of Plant Industry, U. S. Department of Agriculture.

A barkbeetle (*Stephanoderes* sp.) was taken from the terminal twigs of orange trees at Kalihi, Honolulu. The trees were evidently suffering from the disease commonly known as "die-back."

ALLIGATOR PEAR OR AVOCADO.

Twigs were received from Hilo, Hawaii, infested with *Xyleborus immaturus* Blackburn.

The scale insect (*Phenacaspis eugeniæ* Mask.) was taken from the alligator pear in Honolulu.

BANANA.

Two scale insects (*Phenacaspis eugeniæ* Mask. and *Chrysomphalus ficus* Ashm.) were taken during the year on the leaves and fruit.

Chrysomphalus ficus was also taken from oleander, *Amelia* sp., and the fan-palm.

MANGO.

Phenacaspis eugeniæ Mask., on leaves and fruit; taken also from magnolia.

On July 5, 1905, Mr. J. E. Higgins handed the entomologist specimens of the seeds of mangoes infested with the larvæ and pupæ of a beetle. Two days later the entomologist visited a mango district in the vicinity of the place where Mr. Higgins found the infested fruit and obtained larvæ, pupæ, and adults of the same species. Duplicates of these forms were forwarded on July 11 to the Bureau of Entomology of the U. S. Department of Agriculture, and examined and reported upon by Mr. E. A. Schwarz under date of July 26. Mr. Schwarz gives the determination of the weevil as *Cryptorhynchus mangiferæ* Fab., originally described by Fabricius in 1774 and says further: "Its original home is uncertain, for since many years it has spread (no doubt through the agency of man) throughout the 'Oriental Region' from Madagascar through India, Ceylon, etc., to Java and other Malayan Islands. It probably occurs now also in many of the islands of the Pacific Ocean, although I fail to find any records. The species is not enumerated by Sharp from the Hawaiian Islands and is no doubt a recent introduction there. The weevil appears to be extremely injurious to mangoes, and accounts of its ravages are numerous."

Since the life cycle is passed within the seed, and the female, as is customary with the species of this family, deposits the egg in the food of the larva, the insect must have been introduced in fruit or seeds of the mango brought to the islands for propagation from India or possibly the Philippines. It is evident that the fruit is infested in the very early stages of its development, for the reason that there is no indication of the entrance to the seed of the larva through the seed husk. The work of the very young larva is indicated, and since no point of entrance is to be observed it would seem that the length of the life cycle of the insect is somewhat longer than the time of development of the fruit, as shown by the fact that seeds removed from matured mangoes contain the larval weevil.

In the first lot of mangoes examined it was estimated that about 60 per cent were infested—that is, out of 44 seeds examined 28 contained either the advanced larval, pupal, or adult stages. The next lot, examined six days later at the same place, resulted as follows: Sixteen seeds each were taken of the No. 9, the Chutney, and the common "Hawaiian" variety, and of the No. 9, 11 were good and 5 infested; of the Chutney 6 were good and 10 infested, and of the common variety 8 were good and 8 infested. The following varieties planted in seed beds were examined: Twelve seeds each of the Chutney and the No. 1 were selected at random, and of the former 10 were infested and 2 were good, and of the latter 3 were infested and 9 were good. In both instances the Chutney shows the largest number of infested seeds.

SISAL.

Pseudolus longulus Boh. (family Calandridæ), boring in the pole of matured plants. Probably a native of the Hawaiian Islands.

Pseudococcus sp., a mealy bug, very abundant at the base of the inner leaves; preyed upon by the following ladybird beetles: *Coccinella repanda* Muls., *Cryptolæmus montrouzieri* Muls., *Scymnus ocellatus* Sharp, and *S. viridus* Sharp.

The black scale (*Saissetia oleæ* Bernard) on leaves, not abundant.

CASSAVA.

Pseudolus longulus Boh., boring in stalk. (See above.)

Lagocheirus araneiformis Linn. (family Cerambycidæ), boring in stalk; taken also from fig.

TARO.

A mole cricket (*Gryllotalpa africana*) is periodically abundant in some localities. It works on the root.

Aphis sp. (undetermined), abundant on leaves.

GARDEN PRODUCTS.

A leaf-miner (*Plutella maculipennis* Curtis), abundant in the leaves of cabbage. Parasitized by *Campoletis* (*Linneria*) *tibiator* Cress.

The tobacco flea-beetle (*Epitrix parvula* Fab.) was epidemic on tomatoes in one locality during the year.

OTHER HORTICULTURAL PLANTS.

Pseudococcus filamentosus Ckll., on hibiscus, Honolulu.

Saissetia hemisphærica Targ., on *Lawsonia alba* and sago palm, Kapiolani Park, Honolulu.

Dactylopius nipæ Mask. and *Coccus longulus* Doug. on sour sop (*Anona muricata*), Honolulu.

Pseudococcus (*Dactylopius*) *pseudonipæ* Ckll., from palm, Honolulu.

Mytilaspis pallida Green, from croton, Honolulu.

The Japanese rose beetle has been determined by Mr. E. A. Schwarz as *Adoretus umbrosus* Fab. var. *tenuimaculatus* Waterh.

Coccus hesperidum L., on *Ipomœa* sp., Pahala, Hawaii. Parasitized by *Coccophagus immaculatus* How.

Chrysomphalus dictyospermi Morg., on sago palm, Honolulu.

TOBACCO.

The tobacco hornworm (*Phlegethontius quinquemaculata* How.), from experimental field, Hamakua, island of Hawaii.

The Japanese rose beetle (*Adoretus umbrosus* Fab. var. *tenuimaculatus* Waterh.), injurious to young plants in seed beds.

The cigarette beetle (*Lasioderma serricorne* Fab.), infesting cigars, cigarettes, and many stored products.

STORED PRODUCTS.

The following beetles were found infesting fish guano and bone meal fertilizers in a storehouse in Honolulu: *Dermestes cadaverinus* Fab., *Lasioderma serricorne* Fab., and *Tribolium ferrugineum* Fab.

FOREST INSECTS.

Black wattle (*Acacia decurrens*):

Bruchus sp., probably a new species infesting seeds. Australian seeds purchased from a San Francisco firm.

Cyllene crinicornis Chevr. (family Cerambycidæ), abundant. Wide geographical distribution, recorded from Mexico, West Indies, Key West, Texas, etc.

Xytrocera globosa Olivier (family Cerambycidæ), abundant. Occurs also in Japan, Philippines, East Indies, Madagascar, Mauritius, and Java.

Ceresium simplex Gyll. (family Cerambycidæ), not abundant.

Sotenus setiger Sharp (family Cerambycidæ), not abundant. Probably a native of the islands.

Chalcolepidius erythroloma Candèze (family Elateridæ), not abundant. A native of Chile.

Stephanoderes sp. (family Scolytidæ), working in branches of felled trees.

Siphanta acuta Walk., a leaf hopper of the family Fulgoridæ, subfamily Flatinæ, locally known as the torpedo bug; abundant; preyed upon by *Œchalia griseus*.

Icerya purchasi Mask., periodically in evidence. Abundant also during the year on *Casuarina*. Reported as abundant on the island of Maui. Kept in check by its ladybird enemy, *Novius cardinalis* Muls.

The larva of an undescribed moth of the family Tineidæ is very abundant, working beneath the bark of dead or partly dead trees.

Algeroba (*Prosopis juliflora*):

Microcantha nutans Sharp (family Cerambycidæ), not abundant; taken also during the year from fig (*Ficus carica*).

Cyllene crinicornis Chevr. (family Cerambycidæ).

Bostrichus migrator Sharp (family Bostrichidæ); taken also from *Waltheria americana*.

Sinoxylon conigerum Gerst. (family Bostrichidæ). Very abundant in partly seasoned wood.

The bean weevil (*Bruchus obtectus* Say) infests the pods of algeroba to a great extent.

ENTOMOLOGY OF THE HAWAIIAN ISLANDS.

The islands comprising the Hawaiian group have offered peculiar conditions for the development of an endemic insect fauna. It is an insular territory of volcanic origin, the islands being separated by channels varying from 20 to 58 miles across, and the whole group over 2,000 miles from the nearest continent, the California coast. Although lying just within the Tropics, the climate is made semitropical by the prevailing northeast trade winds, giving an almost uniform temperature, the rainfall varying with exposure and altitude. The soils range in character from those capable of supporting a rank and abundant forest growth to those in process of formation from recent volcanic eruption. The islands, situated as they are at the "crossroads" of the Pacific Ocean, have enjoyed an intimate commercial relation with nearly all the important countries of the world, and until tropical and certain temperate-zone countries have been more closely studied it will be uncertain to credit many of the species taken and described for the first time from Hawaii as endemic to the islands. The study of Hawaii's indigenous insects has become a difficult one, for the reason that the invasion of new plants and a new industrial people has caused the natural vegetation to give way to newer forms, or having been destroyed, has been supplanted by cultivated plants or its place left vacant. This of necessity has brought about the destruction of the endemic plant-feeding species of insects and their related parasitic and predaceous insect enemies, or confined them to the remnants of the Hawaiian vegetation found in mountainous districts, and in some instances almost inaccessible places.

To the Rev. Thomas Blackburn undoubtedly belongs the title "the father of Hawaiian entomology." During a residence of some six years in the islands (1877 to 1883) in connection with his profession Mr. Blackburn found time to devote to important work on the insects of the islands in general, and on beetles (Coleoptera) in particular. Not only was his the first important systematic collecting, but his keen appreciation of the rich field and his enthusiasm in obtaining representative material led to further work. As chaplain to the Bishop of the Church of England, Mr. Blackburn naturally referred his material to the scientific institutions of that country, where he possibly earlier had received his knowledge of the subject and the interest which led him to undertake the work. It thus came about that others than the scientists of the United States, under whose province the work would seemingly more naturally have come, have given to us our present knowedge of the Hawaiian insect fauna.

To an American this is of course regrettable, but there is consolation in the fact that certain of the material has been referred to the specialists of our own country for monographic treatment. The regret is not that the work has been done, for the survey of the islands entomologically has been carefully and, in so far as the territory covered is concerned, thoroughly made. The person who has procured the major portion by far of the material upon which is based the present knowledge of Hawaii's fauna, especially in regard to the species peculiar to the islands, is Mr. R. C. L. Perkins, who for nearly ten years has been a persistent and untiring collector in the islands, working under the direction of The Royal Society of London for Promoting Natural Knowledge and the British Association for the Advancement of Science, assisted by the Bernice Pauahi Bishop Museum of Honolulu. The regret that American workers have not participated in the work is that, in the rich results obtained in a territory for many years closely related to and now a part of our own Government, we have seemingly been neglectful of our opportunities, and fail to receive a portion of the well-deserved credit falling to those who have accomplished the work.

The islands as regards plant growth may be divided into (1) the coastal plains and lower slopes of the mountains, devoted to the cultivation of sugar cane as the principal crop, with rice and taro secondary; (2) an area of considerable extent between the "cane lands" and the mountainous districts devoted to grazing on a large scale and the cultivation of coffee, pineapples, corn, potatoes, and other minor crops on a limited scale; (3) forest lands of the mountainous districts; and (4) lands devoid of vegetation comprising recent lava flows, and the areas above the forest belts of the higher mountains. The insects peculiar to the islands are confined in the main to the forest districts, and the lands described under the fourth class offer little of interest entomologically. Passing to a consideration of the economic entomology of the Territory we can see that with the disappearance of the natural vegetation and the natural insects their study is becoming more difficult and, from an economic standpoint, less important. On the other hand, with an increase of the area under cultivation, with the introduction of new plants, and with the commercial relations between other countries becoming more intimate, the study of the economic species is becoming more and more important. These economic species are mainly of foreign origin and many are of comparatively long standing, while others, more noticeable because of their varying work, are of recent introduction.

There is submitted herewith a partial bibliography of the systematic and economic entomology of the Hawaiian Islands.

A PARTIAL BIBLIOGRAPHY OF HAWAIIAN ENTOMOLOGY.

Compiled by D. L. Van Dine.

[Note.—The references marked with an asterisk (*) are in the entomological library of the station.]

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REPORT OF THE HORTICULTURIST.

By J. E. Higgins.

CACAO.

The work on the growing of cacao at Hilo, mentioned in the report for the fiscal year 1904, has been begun and is well under way. A tract of 3 acres has been cleared, plowed twice, subsoiled in part, and prepared for the cacao plants. The field was laid off in five sections, in which cacao trees of different varieties will be experimented with under different methods of treatment. The relative advantages of wide and narrow planting is being tested, including an experiment in double planting, with a view to removing half or possibly three-quarters of the trees as they increase in age and before they become crowded.

Through the courtesy of Hon. E. W. Gurr, of Tutuila, Samoa, the station has received seeds of several varieties. These were planted in some of the sections of the field and also in nursery row. It is not a common practice to plant this tree in nursery form because of the difficulty of removing it in safety. It is a somewhat current belief that it is ruinous to a cacao tree to injure its tap root, but this should probably not be accepted without qualification. Tests will be made in removing the nursery trees.

Through the cooperation of the Bureau of Plant Industry, U. S. Department of Agriculture, this station is promised a collection of the more important and promising varieties of cacao from different parts of the Tropics. These plants, when received, will be planted at once in the field at Hilo.

BANANAS AT HILO.

In connection with the cacao work at Hilo, many experiments with bananas are being carried on. The cacao requires shade, and no plant furnishes a better temporary protection than does the banana. This affords an opportunity to make the land do double duty from an experimental point of view. In the interests of commercial banana growing, which has become quite important at Hilo and the surrounding country, experiments are being carried on with different methods of planting and caring for bananas. It is a somewhat common practice to plant very deeply, regardless of variety, soil, or other conditions. The experiments have already shown that this practice must be modified, but they have not yet reached completion.

It was believed also that a mistake was being made by many planters in the use of very small off-sets. Consequently, a test was begun in the use of off-sets of all sizes as well as of old corms. These experiments are not yet far enough advanced to show conclusive results, but the evidence is in favor of large plants.

The fertilizing of bananas is an important question among the banana growers of Hilo. In a plat devoted to the Chinese, or Cavendish banana, which is the commercial variety in the islands, a fertilizer experiment has been begun in which many different combinations of fertilizing ingredients have been applied. It is believed that the results of these tests will throw some valuable light upon this question, which is of great importance to the industry.

A collection of a large number of native and recently introduced bananas occupies one of the sections, together with 150 or 200 stools of the Bluefields or Jamaica variety, which is being propagated as rapidly as possible for distribution by the territorial board of agriculture and forestry, in cooperation with which the work with this variety is being carried on.

A new commercial variety, it is believed, will be found in the form locally known as the Brazilian, which is probably the same as the Pisang Radjah, or the Pisang Medgi of Java. This variety has not been exported because of its habit of falling from the bunch when thoroughly ripe. It is, however, so superior to the Cavendish variety in many ways that we believe it will pay for greater care in handling when its merits come to be known. In point of flavor it far exceeds any banana now in the American market and is excelled by none grown in the Territory. It seems to be much less subject to some of the diseases which mar the appearance of the Chinese banana and is very much more attractive, being of a clear, yellow color. A large part of the temporary shade for cacao at the Hilo plantation is composed of this variety of banana, the intention being to make experimental shipments of the fruit later to San Francisco.

SHIPMENT AND COLD STORAGE OF TROPICAL FRUITS.

This is a subject which is worthy of much attention. As a beginning a shipment of avocados was made to New York City late in the summer of 1904. These fruits were packed in various ways and received somewhat different treatment before shipment. The results of the experiments are very encouraging in that some of the packages arrived in excellent condition. A few of the fruits were forwarded to Washington, D. C., and were there pronounced by experts to be very fine in flavor. It was, unfortunately, late in the season before arrangements could be completed for making the shipment, and the fruit, being rather too far advanced, the chances were decidedly against its arrival in good condition. At the same time that the shipment was made a few packages of the fruit were placed in cold storage in Honolulu.

The results of these experiments, while not conclusive, point to a decided advantage to be derived from placing the fruits in cold storage as soon as possible after gathering. The ripening process soon begins, especially with fruit which has been rather too long on the trees, and once under way it is difficult to arrest it.

The matter of correct storage temperatures for these and other tropical fruits is one which must yet be worked out. It is quite possible that higher temperatures than those used for temperate zone fruits would be a distinct advantage. The fruits which were kept in the ice house in Honolulu were preserved in good condition and retained their flavor apparently unimpaired for some time after the shipment arrived in New York. After being kept for many weeks, the first signs of deterioration were manifest in a darkened color of the flesh and loss of flavor, though the fruit remained solid. Hence it is quite possible that higher temperatures would prove more successful.

In the matter of packages it seems probable that small forms are preferable. Some of the fruits in the New York shipment were placed in individual sections, such as are used for the packing of glass jelly jars, but no advantage was apparent from this method. The test, however, was not exhaustive enough to be conclusive.

CITRUS FRUITS.

Over 60,000 dollars' worth of citrus fruits are imported annually in the Hawaiian Islands, a territory which affords a congenial home for almost all the species of citrus. To aid those who would grow these fruits, either in the home garden or on a commercial scale, a study has been made of the local conditions relative to this culture and a bulletin (No. 9) treating of the subject has been published. Experimental work has been commenced to determine the merits of different stocks for use in propagating oranges, lemons, limes, and pomelos under Hawaiian conditions.

There are several Hawaiian seedlings of oranges, pomelos, and limes which are of sufficient merit to warrant their perpetuation by budding.

THE MANGO.

Studies of the mango have been continued throughout the year as opportunity offered. Observations were made and records kept of the time of blooming, of the maturing of the fruit, and of the periods of most active growth. About the first of January the mango trees begin to bloom, and by June 30, this season, the mango crop was coming in rapidly. For most varieties the fruiting season was about over by August 1. The seasons, however, vary from year to year, and because sections of the tree often bloom out of season mangoes can be found throughout a large part of the twelve months.

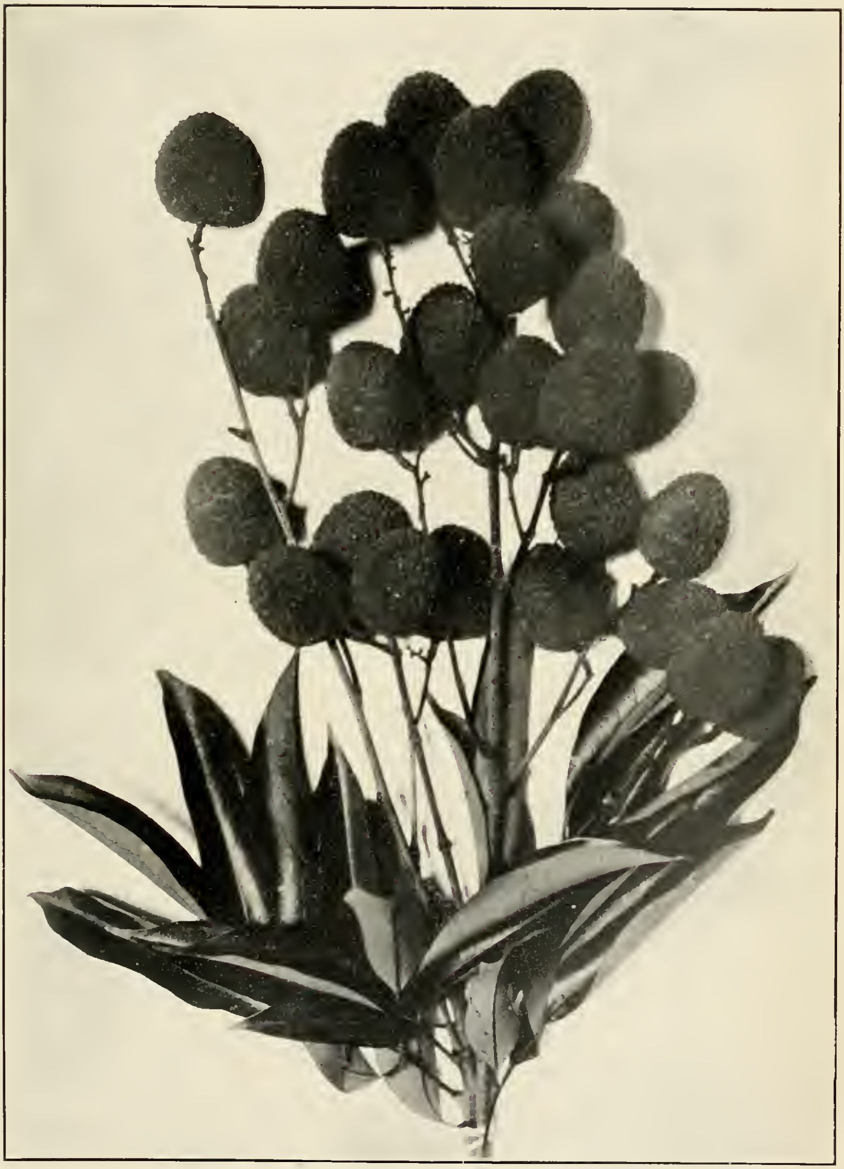
Studies have been made of the habits of growth and fruit production in relation to pruning. The mango requires but little pruning to make it assume a desirable form, but it seems probable that its habit of overbearing one year and producing no crop the next might be overcome by judicious pruning and perhaps by thinning the fruit. It is hoped to take up experiments in pruning with this end in view.

The mango disease mentioned in last year's report, which is due to a species of the fungus Colletotrichum, has been still further studied in cooperation with the laboratory of Vegetable Pathological and Physiological Investigations of the U. S. Department of Agriculture. This fungus has been found present, not only in the fruits, flowers, and young leaves, but also in the old leaves and mature twigs, in some instances apparently destroying the terminal bud before it opened. Experiments in spraying with Bordeaux mixture have been carried on with very encouraging results.

An abnormal character in young mango fruits has been noticed which closely resembles verrucosis of the lemon in outward aspect, but seems to disappear as the fruit increases in size. The cause of this abnormal development has not been discovered. A bulletin (No. 12) has been prepared covering in more detail this and other work on the mango.

EXPERIMENTAL PLATS IN HONOLULU.

In the experimental plats at the lower end of the station lands have been grown 7 varieties of cotton, 2 varieties of papaias, 150 mango seedlings, wood-oil nuts, *Centrosema plumeri*, *Canavalia gladiata* and other leguminous green manuring crops, Manila hemp (*Musa textilis*), *Hibiscus abelmoschus*, and other fiber-producing plants, sugar cane, about 40 varieties of bananas, including several hundred plants of the Bluefields or Jamaica variety, 6 varieties of sorghum and Kafir corn, Rosella (*Hibiscus sabdariffa*), pineapples, garden vegetables, and flowers, cassava, and several other species of economic plants.



LITCHI (NEPHELIUM LITCHI), FRUIT AND LEAVES.

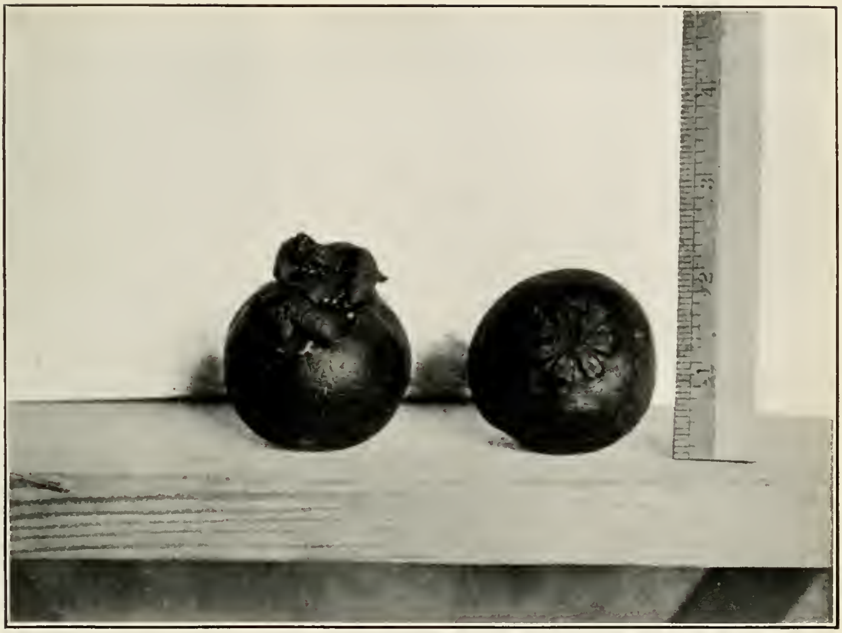


FIG. 1.—MANGOSTEEN (GARCINIA MANGOSTANA).

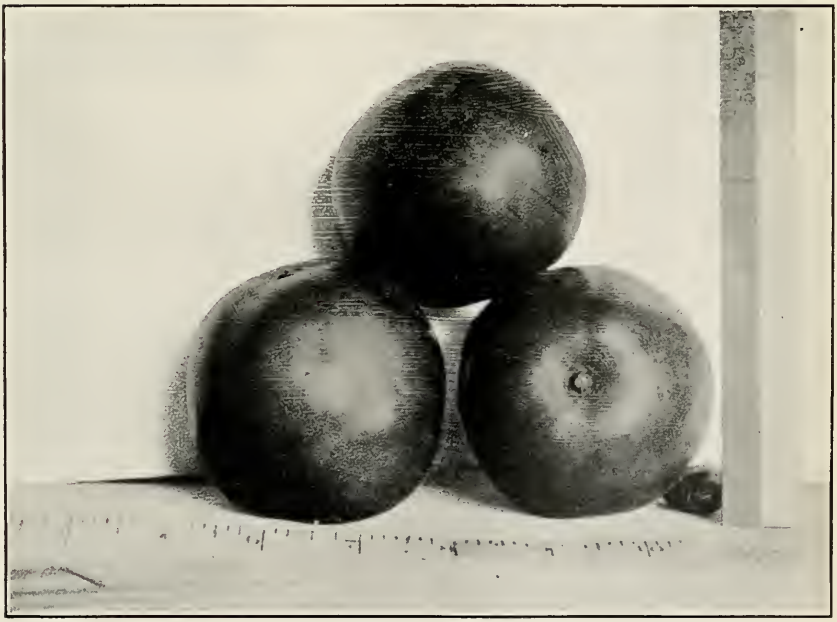


FIG. 2.—WI FRUIT (SPONDIAS DULCIS).

MISCELLANEOUS HORTICULTURAL PRODUCTS.

There continue to be inquiries regarding the cultivation of vanilla. There are in the islands one or two established plantations of vanilla, the best known being that of Mr. Edwards on Hawaii. A brief account of the culture and curing of vanilla has been given in Press Bulletin No. 6 of the station.

The dried fruit of the litchi (see Pl. III) is becoming more extensively known in the markets of the United States, and the successful efforts to grow the trees in Hawaii indicate the possible success of more extensive plantings. The dried fruits from China sell in the Washington market for about 50 cents a box, containing about 1 quart, and the demand for the very limited production in Hawaii is such that the price is very dear.

Attempts are being made by the station in cooperation with the Bureau of Plant Industry of the U. S. Department of Agriculture to introduce more widely the mangosteen in Hawaii. There are already a few trees of this delicious fruit (see Pl. IV, fig. 1) growing in the islands and efforts are being made to propagate others. The tree is of slow growth, and the proper conditions for culture are yet to be ascertained. The successful germination of locally grown seed is reported.

Another fruit that merits attention is the Wi fruit (*Spondias dulcis*). (See Pl. IV, fig. 2.) It is also known as Tahiti apple. It is produced on a tree that attains a height of 50 feet. The fruit is a golden yellow and resembles a pineapple in flavor. It is a native of the South Sea Islands and is now rather widely distributed throughout the Tropics.

A variety of papaias received from Porto Rico Experiment Station as the best form to be found in that island has also proved successful here. Though it has not under our conditions proved itself equal in flavor to some varieties which have been longer in cultivation here, it is worthy of a place in cultivation and will be a valuable addition to the list of forms in Hawaii. It seems to have a more active aperient quality than the local papaias.

Centrosema plumeri promises to be a very successful green manuring crop. These seeds also were received from the Porto Rico Station and have been multiplied here. The plants make a very rapid growth after they get well started and cover the land with a dense mass of foliage which soon begins to decay from below but increases above.

The wood-oil nuts which were received from the Section of Seed and Plant Introduction and Distribution, U. S. Department of Agriculture, consisted of two lots—one in the hulls and the other without hulls. The latter were nearly a total failure, only four or five seeds germinating. The other lot received in the hulls were in good condition, and a very large percentage have made a good start.

The Rosella (*Hibiscus sabdariffa*) has been little cultivated in Hawaii, though it is quite common in Australia, and was long ago introduced to these islands from that source. It makes a good growth on the station grounds, and it is hoped that it will fruit freely. The large fleshy calyx of the flower is both useful and ornamental. It is this part of the plant which is used in the making of a jam which closely resembles in color and flavor that made from cranberries.

At the upper lands, where the rainfall is the only water supply, have been planted coffee, bananas, carnations, violets, and garden vegetables. Some of the land has been cleared of underbrush and terraced, and is now ready for further planting. The mango and avocado trees, which were planted there in the forest before the establishment of the station, have received care and attention so far as available funds would allow. The other trees surrounding them and which threatened their life having been removed several years ago, they are now in promising condition and form quite an orchard of these two tropical fruits.

DISEASES OF PLANTS.

Several plant diseases have received attention during the year. Two diseases of the banana have caused considerable loss, the one being the "ripe rot" and the other the "banana scab."

RIPE ROT.

The ripe rot, or banana anthracnose, is due to the attack of the fungus *Glœosporium musarum*. The disease makes its first appearance on the fruit in the form of small black spots which may increase in area until the whole banana is blackened. This not only destroys its appearance but results in the decay of the fruit before ripening. The fruiting stage of the fungus is marked by roseate tints in which areas spores are readily found in large numbers.

The methods for the control of this disease must consist in precautionary measures and possibly in the use of the copper solutions. Too much stress can not be laid upon the importance of packing the fruit dry. Wet packing and stowing in the hold of the vessel furnish ideal conditions for the growth of the fungus. Decaying fruit should not be left about the fields or packing sheds, as this would furnish millions of spores for the further spread of the disease. Bordeaux mixture and the ammoniacal solution of copper carbonate have not been tested, but from the general character of the disease it is believed that their use is to be recommended at least experimentally.

BANANA SCAB.

Banana scab makes its appearance in rusty fissures in the rind of the fruit. As it increases, the whole banana may become brownish in color, and though the interior may not be injured many such fruits will render a bunch unsalable.

The fungus which causes this disease has not been fully determined. Its appearance has been observed in several countries, notably in New South Wales, where it has been studied by Dr. N. A. Cobb, who speaks of the spores as "of some Phoma-like form."

The disease is widespread throughout the islands but is not serious except on the higher elevations, where the banana makes a slow growth. The copper solutions are to be recommended for the treatment of this disease also. It is important to establish the vigor of the plant by cultivation and fertilization and to avoid the attempt to grow bananas commercially in climates unsuited to them. The fruits should be kept clear of the cast-off bracts and other matter which might hold dampness and thus furnish suitable conditions for the growth of the fungus.

NEMATODES IN BANANAS.

Quite frequently banana plants are found in which the young growing leaves are decaying. Several such plants were observed in June among those planted for shade for the cacao at Hilo. Microscopic examination revealed the presence of myriads of nematode worms which it is believed were the sole cause of the injury. It is nevertheless true that nematode worms have been reported in connection with several banana troubles where fungi were also present.

When a plant is affected as above described it is best to dig out the whole stool, and, after fertilizing liberally, to replant with an offset from a healthy plant.

NEMATODE WORMS IN COFFEE.

In the month of May inquiry came from Kona, Hawaii, in regard to a so-called disease of coffee which was reported to be doing much damage to the crop, causing a large part of it to fall from the trees. A small quantity of the berries was received and an examination was made for evidences of fungi. None were found, however, but nematode worms in large numbers were inhabiting the stem end of the berry and were probably the cause of the falling fruit. Nothing can be recommended in the way of treatment except to increase the vigor of the trees in every way possible.

FARMERS' INSTITUTE.

The horticulturist has acted as secretary-treasurer of the farmers' institute of Hawaii. Four meetings have been held during the year, at each of which three or more papers or lectures have been presented. The membership has been increased so that sufficient funds have been secured to meet the minor incidental expenses of the institutes. No Government funds are available for the carrying on of this work. An arrangement has been made with the Hawaiian Forester and Agriculturist, the local agricultural periodical, so that all papers presented at the meetings are now published and thus made available to everyone in the Territory and also are preserved in permanent form.

U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 171.
A. C. TRUE, Director.

REPORT

ON

AGRICULTURAL INVESTIGATIONS IN PORTO RICO,

1905.

BY

D. W. MAY, M. Agr.,
Special Agent in Charge, Porto Rico Agricultural Experiment Station.

1862 1889

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 171.

A. C. TRUE, Director.

REPORT

ON

AGRICULTURAL INVESTIGATIONS IN PORTO RICO,

1905.

LIBRARY
NEW YORK
BOTANICAL
GARDEN

BY

D. W. MAY, M. AGR.,
Special Agent in Charge, Porto Rico Agricultural Experiment Station.

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1906.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., April 30, 1906.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 171 of this Office the Report on the Agricultural Investigations in Porto Rico for the fiscal year 1905, by D. W. May, M. Agr., Special Agent in Charge of the Porto Rico Agricultural Experiment Station.

Respectfully,
A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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REPORT ON AGRICULTURAL INVESTIGATIONS IN PORTO RICO, 1905.

INTRODUCTION.

The work of an agricultural experiment station in the Tropics is in many ways quite different from that of stations in the Temperate Zone. This seems peculiar, as it would appear at first glance that methods which are successful in the Temperate Zone would prove feasible in the Torrid Zone, but the conditions are so different that presupposed considerations are often in error. The growing season extends throughout the twelve months of the year, but there is quite a variation caused largely by rainfall and perhaps other causes that are not now known. Experimental work in the Tropics is almost altogether pioneer work, for in obtaining results methods worked out in other regions are of no avail and sometimes apt to prove misleading.

With the present knowledge of the methods of dissemination and control of yellow and malarial fevers there is destined to be at an early date a great forward movement in the production and resultant prosperity of the Tropics. Already there is a distinct immigration of northern peoples into this zone, and the returns from capital invested are becoming more and more remunerative. In furthering the interests of this region of the earth, bringing into it increased prosperity, there is no factor capable of doing so much good as agricultural experiment stations. The problems facing these stations are manifold; the questions before the investigator being so many and so varied he appears almost overwhelmed at the beginning of the work. With so many questions for solution it is readily apparent that the men and means available are wholly inadequate to the work in hand. In view of this condition the policy of the Porto Rico Experiment Station is to confine its efforts to a few lines and carry them to a successful issue before taking up others. In selecting lines of work it has sought to develop those productions and methods that with quick results will redound to the greatest good of the inhabitants of the island. It is necessary, therefore, that the first experiments be of a practical nature, leaving the more obscure problems for later consideration.

During the past year there has been a decided improvement in the agricultural conditions of the island. Some crops that have been produced for many years are showing increased plantings, and several crops introduced since the American occupation are yielding a profit and are being extended. While the area of Porto Rico is comparatively small, the climatic conditions, due largely to rainfall, are quite variable. This will result in the predominance of some crops in certain localities. The conformation of the land also has somewhat to do with this matter. At present all low grounds that are at all adapted are devoted to the growing of sugar cane. It will be necessary later to rotate crops on these lands in some systematic way. In such case it is probable rice will be the main crop together with some legume.

COFFEE.

The interior is still and will continue to be largely devoted to coffee growing. Although the prices have not been favorable to the production of this crop, they are growing better, and when the American palate learns to appreciate the peculiar flavor of the Porto Rican berry it is probable that the price will be further enhanced. As will be seen by the report of the expert in charge, the experiment station is carrying on extensive experiments with coffee. These experiments are along several lines as introducing those coffees that bring the highest prices in the States markets, and also increasing the yield and improving the quality of the native product. Some of our importations, as Java and other coffees, will bear their first crop during the year 1905. It will then be possible to determine the quality of these coffees when grown under Porto Rican conditions. We have demonstrated that both the yield and quality of the Porto Rican berry can be greatly improved by better cultural conditions. The average production per tree in Porto Rico is much under 1 pound, while some of the new trees in the station grounds that are just coming into bearing are producing over 2 pounds per tree. This has been brought about by selecting good seed for planting in seed beds and by setting in the field only the strongest and most vigorous plants; also by pruning and thoroughly cultivating the trees until they come into bearing.

Some of the introduced varieties have fruited this year, and it has been possible to test in a preliminary way the relative merits of some varieties of Philippine and Hawaiian coffee. These varieties are believed to be inferior to the Porto Rican varieties, but some choice Ceylon varieties retain their characteristic flavor when grown under Porto Rican conditions. This is considered very encouraging, as it seems to indicate the possibility of growing varieties that bring the highest prices in the world's market without loss of their peculiar flavor and other qualities. It is hoped that it will be possible to report on a number of high-class Mocha and Java coffees next year.

This investigation is awakening wide interest among the coffee planters who are adopting improved methods of culture. It has been the custom formerly to take up wild plants growing in the woods, set them at the proper distance, roughly prune them with a machete, and give them little or no cultivation.

CANE.

Since the American occupation cane growing has undergone an entire revolution. American capital has come in and built large sugar mills or centrals, resulting in the abandonment of the many smaller mills which dotted the cane regions. The cane growers find it more profitable to sell their canes to the large centrals than to grind them in their small mills, often using oxen for power and boiling the juice in open kettles.

Some of the larger centrals are carrying on experiments in growing cane and they are very urgent that the station undertake experiments in this line. Some experiments with cane have been taken up by the station, but our limited funds prevent very extended work in this line. By cooperating with some of the larger plantations the station hopes to obtain some valuable results along certain lines in cane production. At the present time the greatest interest is in the methods of planting and the proper fertilization of this crop. The fertilization of Porto Rican soils is very important as it has not had much attention in the past, and it is not known just what these soils most need. The results of preliminary tests indicate that cane responds very readily to commercial fertilizers, and while no very definite conclusions can be drawn at this time it seems that fertilizers containing the three elements—nitrogen, potash, and phosphoric acid—are advisable. On the ground of the station potash showed especially favorable results.

In buying fertilizers in Porto Rico planters are urged to buy high-grade goods. It is of course the nitrogen, potash, and phosphoric acid that constitute the value of a fertilizer and, owing to the high freight rates, there is no advantage in transporting an excess of filler in the goods. The last legislature of Porto Rico passed an act, prepared by the experiment station, providing for the inspection of fertilizers sold in the island. This forms a guaranty enabling the planter to protect himself in the purchase of fertilizers, and at the same time the printed label enables him to follow more closely the composition and the results of its use.

The station is securing some of the more promising seedling canes with the object of introducing these, after trial, upon the plantations. As in the case of many of the other economic plants of Porto Rico there is great need of breeding up the varieties of cane now grown. The centrals have been purchasing canes upon gross weight and are now discriminating in price only with varieties. With the economies that are coming in sugar production in Porto Rico they will shortly estimate the value by the sugar content, therefore improvement in cane production must proceed along several lines. Not only must the gross yield be increased but the percentage of sugar in the juice must be raised. Again, it is observed that some varieties are more resistant to certain insect pests and fungus diseases. One well-known variety that has been grown in Porto Rico for many years is now being abandoned because of insect depredations toward which other varieties are resistant.

At this writing no very serious insect pests or diseases are prevalent in the cane fields, although with the largely increased plantings and lack of rotation such are likely to occur. Some such outbreak came about thirty years ago, when cane growing in Porto Rico was passing through one of the more prosperous periods of its history. Lately some diseased canes were brought to the station that were infested with larvæ of a species of Sphenophorus. The person on whose plantation it was found said the cane presented much the same appearance as during the serious trouble in the seventies.

The moth borer (*Diatræa saccharalis* Fab.) has been reported as doing damage in various sections. It is advised that cane seed be soaked for twenty-four hours in limewater before planting to destroy this pest and also as a hindrance to other troubles that might be present in the seed. This practice is also believed to favor the germination of the seed.

A further experiment has been made along this line to test the influence of several solutions on the germination and early growth of canes. Less than 5 per cent solutions were made up of lime, magnesia, lime and magnesia, ammonia, nitrate of soda and a mixture of nitrate of soda, acid superphosphate and muriate of potash. The canes soaked sixteen hours in a solution of lime and magnesia germinated quickest and made the best early growth. That soaked in limewater was next in thriftiness. The canes soaked in the ammonia water germinated second best but in a short time fell behind. Those soaked in the other solutions were slower in starting and less thrifty than those in the check plat, which were not soaked at all.

Besides the growing of cane the station has taken up some problems in the utilization of the by-products of cane. At present a great many oxen are used on the plantations, and as more and more land is being broken and planted the feeding of these animals is becoming a serious question. During the grinding season cane tops are fed in large amounts to the oxen and it seems possible that a way may be found for preserving these for future use. As a dry feed they do not seem to be relished, but it is probable that some means may be found for properly ensiling them. With these and other by-products of cane production and manufacture, like molasses, it is not improbable that in the future not only the work animals but large numbers of beef cattle will be fed in the neighborhood of the centrals. At present the molasses is shipped to the States and incorporated in specially prepared stock feeds.

TOBACCO.

During the year the station issued a bulletin (No. 5) on Tobacco Investigations in Porto Rico. This includes a description of tobacco soils and methods now followed in growing tobacco in Porto Rico. Experiments in growing, curing, and fermenting tobacco are described in detail, and suggestions made for the improvement of our tobaccos both in culture and fermentation and in seed improvement. Our tobacco expert resigned to enter the Bureau of Plant Industry of the U. S. Department of Agriculture, and since that time no work has been carried on with the cigar tobacco growing in the interior. It is very necessary that further studies be made with this important crop, should our means allow. The tobacco soils of the island should be mapped out and further studies made of their fertilization. Researches with the curing and fermenting of cigar tobaccos are very much needed.

Some of the larger companies located in the interior valleys are producing a very fine quality of tobacco, both filler and wrapper. The soils of the station and their proximity to the sea forbid the production of the finer qualities of cigar tobaccos. Experiments are being carried out, however, in the production of other kinds used in manufacturing. It has been found that the White Burley, such as is grown in Kentucky, does very well on the soils of the station, producing a very large fine plant. Further experiments are being carried out with this variety.

COTTON.

There has been quite an increase in the area devoted to sea-island cotton in Porto Rico. This has been fostered by the experiment station, which distributed several tons of improved seed to various sections. The special agent in charge has also prepared during the present year a circular on cotton growing, which has been distributed over the island.

The quality of the cotton grown in Porto Rico is very good and it is a crop that is especially adapted to the country, because the poorer farmers can produce it in limited amounts without the aid of capital and employ their families in the various operations in its production. There is no boll weevil in Porto Rico, and the only insect pests reported as in any way seriously affecting the crop are the cotton caterpillar (*Alabama argillacea* Hbn.) and the cotton stainer (*Dysdercus suturellus* H.-Schf.). The cotton caterpillar has caused serious damage in a great many fields. Although this insect has been on the island as far back as records go, it does not become a serious pest until the extended plantings of cotton permit it to increase in unusual numbers. It is found all through the Southern States, and since effective measures have been developed to combat it its depredations are not serious. It is highly important that our planters keep on hand a certain amount of Paris green unless in a position to obtain it quickly. This caterpillar marches like an army and, unless stopped, it will very rapidly devastate a field. It has appeared twice at the experiment station, but was readily checked by the use of Paris green mixed with lime, 1 part of the former to 8 parts of the latter dusted on the plants.

The experiments with cotton at the station have been somewhat extensive, following several lines. Two varieties of sea-island cotton are on trial and quite a number of Egyptian cottons procured from the United States Department of Agriculture, Bureau of Plant Industry. So far indications point to the sea-island cotton as the most profitable for Porto Rican conditions. The Egyptian cottons at the station have made a very rank growth, but the production has not been as good as expected, due doubtless to the excessive rainfall. These varieties will probably do better in the drier sections, especially where irrigation is practiced.

Our experiments with fertilizers indicate that the three elements of plant food are needed in Porto Rican soils, but more especially potash and phosphoric acid. With the first crop on most soils not much fertilizer is recommended, but it is advisable to use a little containing nitrogen, phosphoric acid, and potash. This will in all probability prove remunerative, will tend to interest the planter in the needs of his soil, and will start him in properly using fertilizers upon which the success of Porto Rican agriculture so much depends.

It is proposed to issue a bulletin on growing this important crop, and it is hoped that the area now planted will be extended in the island. It is estimated that during the year there were between 6,000 and 7,000 acres planted to sea-island cotton and that the yield will exceed 5,000 bales.

There is no especially discouraging feature to cotton growing in Porto Rico. The cotton caterpillar has caused losses, but as it is easily combated the planter should not become discouraged. It is probable that this insect will decrease the cotton acreage during the season of 1906 and perhaps for several seasons.

There is much to be desired in cotton culture in Porto Rico. Better methods of culture must be followed in order to improve the quality of the fiber. This should begin with the selection of the seed and end only with the delivery of the lint to the gin. Improved seed only should be planted, and all wild cotton destroyed to avoid contamination of the seed produced. Better culture must be given our cotton and it must be fertilized. Old cotton plants must be destroyed and not allowed to grow into a tree. Such cotton is inferior and the yields are too small. Because cotton grows naturally in Porto Rico the industry must not be given over wholly to nature.

CORN.

Some corn is grown in certain sections of Porto Rico, but its production should be greatly extended. The native varieties especially need improvement, as they are small, with large cobs and inferior grains. The station has been experimenting with corn from seeds grown in the States and also in improving the native varieties; so far our results with seeds from the States have not been promising. There is some peculiar condition here that prevents such corn from properly developing. This reason has not yet been determined, but it is hoped that some way will be found to utilize the improved varieties from the United States. In the meantime the station is endeavoring to develop an improved corn from native seed. Doubtless in time a very fine variety will be obtained, but could corn from the States be grown here that result would be reached much quicker.

The only serious insect pest on the corn plant is the cotton bollworm (*Heliothis obsoleta* Fab.), which attacks it during most seasons of the year. This is especially bad in regions of the greatest rainfall. It is rather hard to combat this insect, and planters as a rule in corn-growing sections plant at those times when the insect is less numerous.

RICE.

Porto Rico imports annually large quantities of rice, which constitutes a large part of the food of the people. By far the larger amount comes from the port of New Orleans and consists of the cheaper grades of the Louisiana rice. At the present time small patches of upland rice are grown, but there is practically none of the lowland rice. It will be necessary to introduce rotations on those fields devoted to cane, and rice will probably prove the most profitable crop to use in such a rotation. Those fields that are now well fitted for irrigation can be very readily devoted to rice growing. But to grow rice successfully in Porto Rico in competition with other countries, it will be necessary to use machinery as in Louisiana.

Although labor is plentiful and cheap, it can not compete with machinery in the production of this staple. The experiment station is growing rice in an experimental way under irrigation, and so far the indications are that this crop can be very successfully produced in Porto Rico. It is practically a new industry and it will probably be several years before it will assume the position that its importance warrants. At present the plantings of upland rice consist of small patches about the cabins of the poorer classes, who harvest the grain with the sickle and pound it out with hand mills.

POTATOES.

During the past winter (1904–05) a number of experiments were carried out in growing potatoes from northern-grown seed; five varieties in all were tested, the best results being obtained from Bliss Triumph and Early Rose. The yields were fair and the quality very good. The only serious pest developed was a blight which was kept in check with Bordeaux mixture. Some of the potatoes produced were shipped to San Juan and New York. As Porto Rico imports large quantities of potatoes every year, it is probable that prices will be better on the island during all seasons except late winter, when it may be profitable to ship to the States. During the coming winter (1905–06) several acres will be planted to potatoes, and shipments will be made to the principal cities of the island and to New York. The experiments made during the past winter indicate that under proper conditions potatoes may be grown successfully in a commercial way in Porto Rico. It is not thought that the section represented by the experiment station is favorable to this crop, owing to the heavy nature of the soil and the excessive rainfall. It is probable that the higher altitudes are better suited to the potato. There are no serious hindrances to growing potatoes that are peculiar to Porto Rico while the local demand is good and constant, large amounts of the tubers being imported annually from Spain and the United States. In growing potatoes in the island, however, the planter is advised to fertilize heavily and to spray often with Bordeaux mixture.

FORAGE CROPS.

The principal forage crops of the island are malojillo grass and Guinea grass, the former growing on low ground and the latter on the foothills. These are both very nutritious grasses, but they make heavy draughts on the soil, and the primitive methods of cutting and feeding by hand are expensive and crude. It would be far better for the soil if leguminous forage crops were grown instead of these grasses. The sterile and inhospitable condition of many soils is often due to the repeated removal of these grasses from the land. Fields are sometimes kept in cane from three to six years and are then allowed to grow up in malojillo grass. This grass is then cut for a number of years and sold off the land. Such a system of agriculture must ultimately result in a very poor physical condition of the soil. Even with the application of large amounts of commercial fertilizers they lose much of their usual effectiveness because the physical condition of the soil is so poor.

The station has a series of plats laid off for testing various legumes and other forage crops. (Pl. I.) Of the legumes the cowpea is the most promising. Quite a number of varieties have been planted and all do well when the soils are inoculated. The earlier varieties produced ripe seed in seventy days. The only serious pest of this crop is the leaf hopper, which cuts a good many holes in the leaves, but not enough to damage the plant greatly. The rainfall in the vicinity of the station is very heavy, and soils for cowpeas should be fairly well drained. In some of the drier sections it is probable this crop will do even better than at the station. In general the cowpea in its growth does not materially differ from the same plant in the States, except that the stem is somewhat thicker. A number of varieties have been planted throughout the twelve months, and while all seasons are favorable to their growth, they do better in regions of heavy rainfall if planted during the drier months.

This legume is one of the finest soil renovators known, not only storing large amounts of nitrogen in the soil, but leaving the ground in fine physical condition. It has been reported as doing well in the north side of the island among the orange groves. Any section growing cowpeas may have no fear of failure in improving the condition of its soil. The growth of this legume is one of the most promising developments of Porto Rican agriculture. (Pl. II, fig. 1.)

The beggar weed makes a fair growth, but does not reach the height it does on the light sandy soils of Florida. It will, perhaps, do better on the lighter soils of Porto Rico. In sandy soil on the north side of the island it has made a very rank growth. It is somewhat damaged by the same leaf hopper that troubles the cowpea.

Velvet beans do well on the station grounds and do not seem to be seriously damaged by insect or fungus pests. They do not make a rank growth on the heavy clay soils at the station, and for a quick growing crop are not equal to the cowpea.

Alfalfa on soil properly drained and inoculated is a very promising crop. The plat sown to this is now in full blossom three months from seeding, and it is the best the writer has seen anywhere at that age. Further observation will be necessary, but at the present it appears to be a very promising crop for Porto Rico under proper conditions. So far no insect or fungus pests have developed. This crop has been sown on a piece of well-drained land near the river, which is largely composed of clay and rather heavy for alfalfa. Our experiments on heavy clay upland soils have resulted in failure.

So far red clover, Japan clover, and Genge clover have not done well, but further trials are advisable. Clover sown in the Tropics should follow some hoed crop, and the ground should be fertilized with barnyard manure in order to get a quick stand. There are certain rank-growing grasses that spring up so quickly that there is a tendency for them to choke out the clovers unless conditions for the germination and quick growth of the latter are favorable.

Two varieties of Phaseolus from India have grown well on wet soils and in wet weather. They are not equal to cowpeas and it is not advisable to grow them where the cowpea is well suited. The same may be said of certain navy and other beans which may be grown for fertilizing the soil.

All varieties of lupines and vetches have failed to make satisfactory growth. They germinate but do not grow higher than a few inches. Lupines will blossom at about 5 inches high but make no further growth.

In testing legumes in a section new to them conclusions can not be drawn from a few trials only. Given suitable conditions, the legumes adapt themselves better to the Tropics than most any other plants. The matter of inoculating the soil with the proper nitrifying bacteria is one point that often marks the line between success and failure. Again, there is a question of acclimatization that must be solved. In general it seems advisable to repeat trials of legumes on the same ground, one trial after another, until the question of adaptability is thoroughly tested.

Sunflowers, like some other plants of the Temperate Zone, make a very quick but stunted growth. This striking difference in the growth in the Tropics is very peculiar with a number of plants and it is difficult to understand. Sweet corn, for example, sometimes makes a growth of about 2 feet in fertile soil, bearing tassel, and apparently going through all the stages of maturing. The natural conditions, as far as we are able to determine, are very similar to those under which the plants will flourish in the Temperate Zone, and at present no reason can be found that will explain this peculiarity. It is probably due to some factor connected with the soil.

Some experiments are under way with sugar beets and roots of fair size have been obtained. The sugar content has not yet been determined. The plant is very subject to blight in the later stages of growth. While the sugar beet can not compete with cane in the production of sugar in the Tropics, yet it might find a place in agriculture under certain circumstances; for instance, on the south side of the island some soils are so alkaline that no cane can be grown upon them. In cooperation with one of the plantations containing such soils an effort is being made to grow sugar beets, hoping thereby to remove the alkali with the crop of beets, so that ultimately cane may be grown. The beets can be put through the mill and yield a profit from the beginning, provided, of course, the sugar content is somewhat near that of beets grown in temperate regions.

Turnips and kale have also been grown in the experimental plats, and they do very well. These will doubtless prove of some value as an additional forage plant in the rations of live stock.

VIEW OF A PORTION OF THE STATION PLATS, MAYAGUEZ.

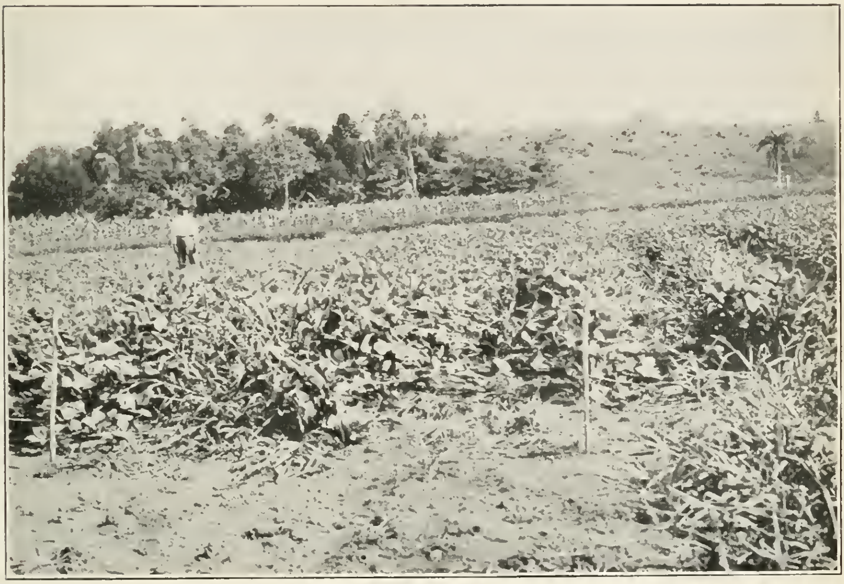

FIG. 1.—COWPEAS FORTY-NINE DAYS FROM SEEDING.

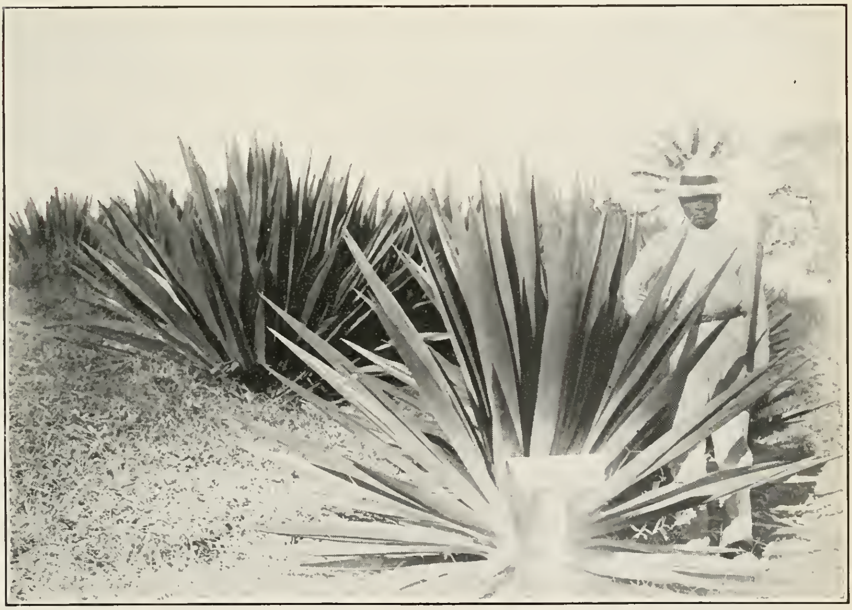

FIG. 2.—SISAL PLANT TWO AND ONE-HALF YEARS OLD.

Peanuts are grown in all sections of Porto Rico, the sole variety being the small red Spanish. Improved peanuts from the States have been planted and have been found to do as well as the Spanish variety in the experimental grounds of the station, and seed produced from these have upon replanting given equally favorable results. The high food value of this plant being well known, together with the fact that it is a nitrogen gatherer, its planting is recommended for all sections of the island.

Horse beans have made only a stunted growth of some 12 inches in height and have flowered; so far in our experiments they are classed as a failure. A number of other forage plants have been tested, but at this time no report can be made; some experiments have not gone far enough and others have failed for the reason of nongermination of seed. It is found that seed deteriorate very rapidly in this climate, probably on account of the great variation in the humidity of the atmosphere between day and night.

FIBERS.

Experiments with fiber crops as reported last year are being continued, with one or two additions. Indian hemp (*Cannabis sativa*) has been tested, but made a very poor and stunted growth. Of the other fiber crops that have been under test, sisal seems to be the most promising from a financial point of view. Maguey grows luxuriantly and is native to the island, but the yield of fiber is small compared with sisal. Sansevieria will make a good growth on certain soils, but the yield of fiber is much below sisal, and the soils that will grow this crop will also grow more profitable crops, like sugar cane. On high ground that plant makes a very meager growth. The insular government has decided upon taking up the growing of sisal on a commercial footing, setting 100,000 plants under the direction and supervision of the experiment station. The fiber expert of the Bureau of Plant Industry, U. S. Department of Agriculture, Mr. Lyster H. Dewey, made a visit to the island in the summer and looked into the fiber situation in different sections. He recommended that a commercial trial be made with sisal as the most promising of the several fiber crops tested by the experiment station. Upon his return to the States, a box each of sisal and maguey were sent to Paterson, N. J., for extraction in the machines. Mr. Dewey returned samples of these fibers extracted. Commenting upon that from the sisal, he writes as follows:

> This fiber is softer and more grayish in color than most of the sisal on the market, owing chiefly to the fact that it is from leaves only 2½ years old, while practically all of the commercial sisal fiber is obtained from leaves at least 4 years old. This fiber, however, is of remarkably good strength (Pl. II, fig. 2).
>
> We tried the maguey leaves in the machine at Paterson, but the machine would not clean them in a manner at all satisfactory. The fiber of the Porto Rican maguey is weaker than that of sisal and the leaves are less firm in texture.

FLOWERS.

There are many very pretty flowers native to Porto Rico, and with a little care homes may be made quite beautiful with them. There is a lack of systematic planting, however, and much to be desired in improving the quality of the plants. Roses especially do very well in this section of the island.

The native roses are small and not well adapted to use as cut flowers. The station has introduced many roses from the States, all of which do well, especially the climbers. Noisette or tender climbing roses like the Marechal Niel grow very rapidly and produce many very large, handsome flowers.

The dahlia makes a very rank growth and under proper treatment will produce very fine bloom. Hollyhocks grow and blossom readily. Cannas and caladiums are native, found wild, and lend themselves very readily to improvement. Geraniums grow very slowly and bloom sparingly. So far they can not be said to be a success. Lobelia and pansies have been grown in shady locations with much care, but they are not very vigorous. Carnations make a spindling growth and inferior bloom. Sweet peas indicate that success will be attained under proper methods of growing; some trials have failed utterly, and others have produced a small amount of nice flowers. Begonias do well; salvia only fairly well. Many other ornamentals are under trial and will be reported upon later.

LIVE STOCK.

The station has purchased from farm receipts a stallion registered in the American Saddle Horse Breeders' Association (Pl. III, fig. 1). It is very much desired that the quality of the Porto Rican horses be improved, as they have very seriously deteriorated. At present they are small and a great many unsound. Several importations of horses have been made into the island, and in the writer's opinion the lighter breeds, like the standard bred American trotting horse and the saddle stock that has sprung from the thoroughbred, are better adapted to Porto Rican conditions. One importation of 20 head of Norman horses, made by a sugar company, has not turned out very well, a number of them having been lost. These heavy draft horses unlike those of lighter breed, can not withstand the warm climate. Quite a number of mules are now being imported by the sugar planters and are supplanting the oxen on the plantations. Mules do very well where properly handled. The station owns 5, which have been on the island from two to five years. The native mules are small and used only in the interior as pack animals; they will not do for work on the cane plantations.

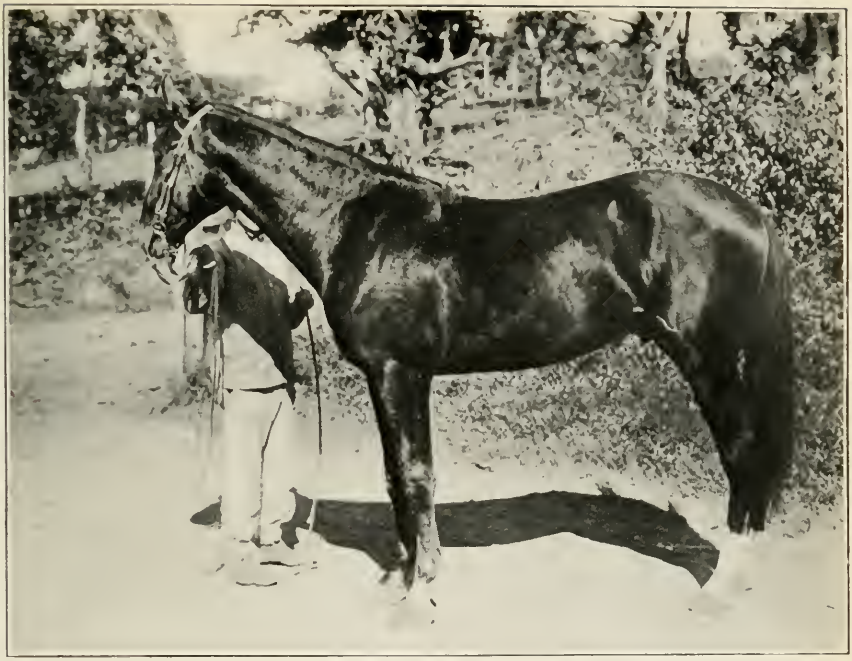

FIG. 1.—SADDLE-BRED STALLION, THORNTON McDONALD 2237.

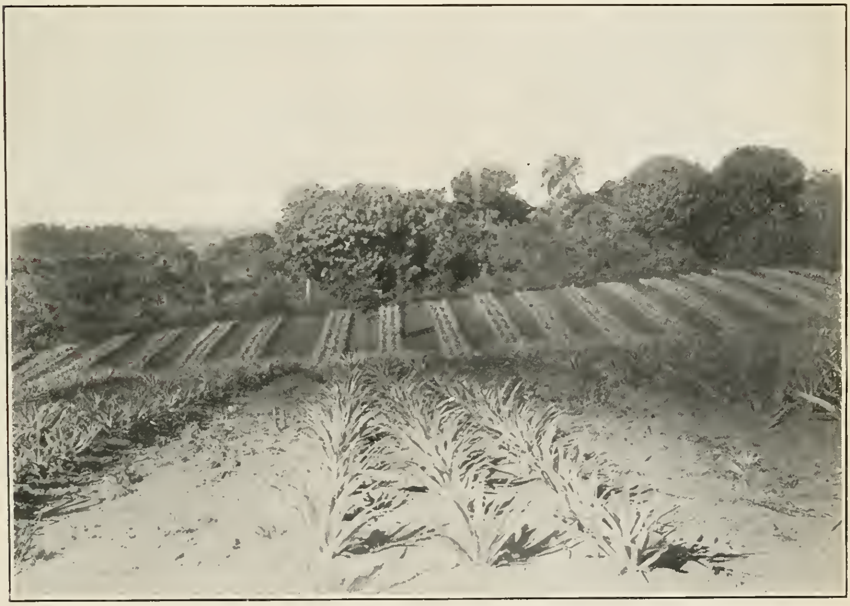

FIG. 2.—CABEZONA PINEAPPLES, SHOWING METHOD OF PLANTING.

Some cattle have been imported during the year, and from results it is probable there will be more brought in from year to year. The native cattle will doubtless lend themselves very readily to improvement, needing especially to be bettered in the line of early maturity and milk production. As work cattle they are very fair, and considering the lack of care in breeding they are remarkably good.

Porto Rico is infested with one of the cattle ticks, *Boophilus australis*, and it is necessary that imported cattle be inoculated either before or immediately after landing to prevent them from contracting tick fever. Two shipments of inoculated cattle made during the present year have done very well. The three head that were left at the station for a time apparently showed no signs of tick fever. A later importation of cattle is now at the station undergoing inoculation against this disease. There is a belief among some stockmen that tick fever does not prevail upon the island, but the Bureau of Animal Industry of the U. S. Deparment of Agriculture has received ticks from Porto Rico and has infested cattle in the States with them, bringing on the disease. The station is further testing this question in cooperation with the Missouri Station, and until definite instructions to the contrary are given all cattle coming to the island should be inoculated unless they come from below the quarantine line.

Some sheep are raised in Porto Rico, but their condition can not be said to be thrifty. They lose a great part of their wool, and in the section of greatest rainfall are very liable to disease.

Goats are found all over the island and add much to the nourishment of the poorer people. The station is endeavoring to obtain imported milch goats of Swiss breeding for the improvement of this class of animals. A great many sections of the island, in the interior especially, are adapted to goat raising and to no other class of animals.

Several importations of swine have been made into Porto Rico and, as far as the writer's knowledge goes, all have done well. The native pig is of the razor-back type, and it does not seem advisable to try to improve it, but rather to substitute pure-bred stock. No hog cholera or swine plague prevails on the island so far as the writer's experience goes.

All classes of poultry thrive in Porto Rico, but the stock found at present is greatly in need of improvement. Chickens consist mainly of the game breed, and are small and active, but not well adapted to meat or egg production. Several importations have done well. Ducks thrive, and quite a number of turkeys and guineas are raised. There is a good local demand for poultry products, and there are no serious hindrances to the production.

MISCELLANEOUS NOTES.

At the last session of the legislature, the old Spanish station, consisting of 7 acres of land and a few buildings adjoining the Porto Rico Station, was turned over to the latter. This makes altogether 242 acres in the station farm. In the Tropics it takes more capital, labor, and teams to cultivate land than in the Temperate Zone. The growing season extends throughout the year, and there being no frost to clear the land, it quickly grows up to wild grasses when not tilled. For this reason only a portion of the station farm has been planted. The low grounds have all been tile drained and planted to various field crops and vegetables. The high grounds have been planted to fruits of various kinds, including citrus fruits, pineapples, etc., and also cotton, cassava, sweet potatoes, broom corn, and cane.

During the year Mr. O. W. Barrett, entomologist and botanist, resigned to enter the U. S. Department of Agriculture. It is hoped to fill this position at an early date, and also to add during the coming fiscal year a chemist to the staff, and to build a chemical laboratory. No appropriation was made by the insular legislature for the assistance of the experiment station and no outside funds have been received. The farm receipts have increased somewhat in amount, exceeding $1,000. Cooperative work has been carried on with the Bureau of Plant Industry and the Irrigation and Drainage Investigations of the Office of Experiment Stations. The station has cooperated with the insular authorities in the enforcement of a fertilizer law passed by the last session of the legislature, and also in the enforcement of a plant inspection law.

The needs of the station are very urgent, as the work is developing quite rapidly in several directions. It is very important that more time be spent among the plantations investigating various troubles and advising the planters. The station needs the services of an entomologist, but there is so much work to do in both entomology and plant pathology that it would be advisable to have a man to follow up each line of research. It is also highly important that a chemist take up the study of Porto Rican soils and the proper fertilization of the same. There is also very much need that the waters used for irrigation purposes be examined and analyses made of the deposits of guano found in the many caves of the island.

Two farmers' institutes were held during the year—one at Bayamon and one at Rio Piedras. It is hoped to hold more during the coming year in other sections. Many trips have been made through the island by different members of the station staff in visiting the plantations. It is very important that this work be extended, and it is believed to be one of the best means of reaching the planters and rendering assistance to them in their work.

During the past year besides the Annual Report for 1904 the station issued Circular No. 5, on Coffee Growing in Porto Rico; Bulletin No. 5, on Tobacco Growing in Porto Rico, and Bulletin No. 6, on Yautias or Taniers.

REPORT OF THE ENTOMOLOGIST AND BOTANIST.

By O. W. Barrett.

Following is a brief account of the various lines of work conducted by the entomologist and botanist, until the spring of 1905, when he severed his connection with the station.

The lines of work were more or less identical with those carried on in 1904. During July, August, and September attention was directed largely to the study of the coffee leaf-miner parasites and toward the general study of the fungus diseases of native crops. The various collections of native crops, like yams, yautias, etc., were harvested during December and January and replanted on a larger scale in January and February. Many specimens were added to the herbarium.

The banana collection was increased by the addition of the Cuban varieties, and so far as possible the eighty-five or more numbered sorts were classed into distinct types, which were mostly grouped in the permanent variety test plat in the alluvial soil between the station office and the river Yaguez. It was found necessary to allow about twelve groups or types to contain the said number of varieties. During the arrangement of this collection it was discovered that several native varieties, largely believed to be identical, were quite distinct as regards the fruit itself. It is hoped that this test plat of banana varieties from various tropical countries of the world will definitely decide the question of synonymy of the local names, as well as decide several questions in regard to the adaptability of certain types to the manufacture of banana flour, banana coffee, etc.

The yautia collection was increased by the addition of a few varieties from Panama and Central America. The present number of varieties under observation is about fifty. A bulletin[a] giving a general résumé of the subject, together with the results of fertilizer tests, analyses, and prospective uses of the tubers, which, so far as is known, is the first bulletin to be issued on this subject, has been published. The crop is believed to be the oldest one in the history of agriculture.

The cassava collection was enriched by the addition of a full set of the Colombian varieties, secured in Jamaica by Prof. P. H. Rolfs, of the Subtropical Laboratory of Miami, Fla. About fifty named sorts are now on the variety list.

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[a] Porto Rico Expt. Sta. Bul. 6.

Roots of ramie (*Bœhmeria nivea*) were set in a moist location near the propagating house, where they rapidly attained a considerable height. The plat of cadillo (*Urena lobata*) attained 12 feet in height, and the plants were almost branchless on account of the thick stand which was allowed to grow from volunteers. Samples of this fiber were prepared both by retting and by the dry stripping process; though the strength is great, the interlacing of the separate fibers is prohibitive to their successful combing by machinery. The Bahama sisal and the native maguey plants continue to make a good growth, while the plants of the "Cocuisa" do not show a satisfactory growth.

On account of the large number of seeds and plants received in exchange from botanical stations in the West Indies and other tropical countries, it was decided to lay out a small botanic garden for the reception of those plants which did not properly belong either in the forest plat or in the fruit orchard. About fifty species of more or less economic importance were set in permanent positions in the coffee grove north of the station office; coffee trees were left for shade.

Experiments in the manufacture of starches and flours from various native roots and fruits were continued throughout the greater part of the year. Samples of these products were sent to the Bureau of Chemistry of the U. S. Department of Agriculture and to several food experts. Some of the results were decidedly promising. Work with the banana coffees was also begun, but not completed; the varieties of plantain gave the best results both for a well-flavored flour and for a coffee substitute. Several varieties of cassava, especially those having bright yellow roots, appear to be particularly adapted to the manufacture of a flour which can be used for nearly any purpose to which wheat flour is adapted. The distinctive flavors are fairly well retained if the sliced roots are dried at a low temperature. Several varieties of yautias, particularly those having pink or purplish tubers, produce attractive looking flours which retain the highly nutritious and delicately flavored properties of the fresh tubers.

INVESTIGATIONS IN ENTOMOLOGY AND PLANT PATHOLOGY.

A second parasite of the coffee leaf-miner (*Leucoptera coffeella* Stain.) was discovered working in the same leaf mines with the common *Chrysocharis livida* Ashm. This rare parasite, which seems to be strictly primary, has been determined by Dr. William H. Ashmead as *Zagrammosoma multilineata*, and was first described by him from the locust leaf Tineid (*Lithocolletis ornatella* Chambers) of Kansas. Samples of infested coffee leaves were requested to be sent in to the station from all sections of the island, and, contrary to expectations, the parasite *Chrysocharis livida* proved to be distributed throughout the island; hence the breeding experiments were discontinued. The action of the latter parasite at the experiment station grounds has resulted in the almost complete destruction of the coffee leaf-miner, although one year previous each coffee plant at the station grounds carried on an average something like twenty-five larvæ of the leaf-miner. Unfortunately, the good results of the parasites' work were not so much in evidence in other sections of the island.

The several insects injurious to cotton were studied during the year and a large cotton plantation was visited in the vicinity of Aguadilla, where great damage by a caterpillar had been reported. It was found that although the cotton caterpillar (*Alabama argillacea* Hbn.) had been somewhat destructive in small areas through the plantation the pupæ were nearly all parasitized. *Chalcis annulata* Fab. was reared from a few pupæ which were obtained in the plantation.

Ten species of mosquito-eating dragon-flies were studied on the station grounds.

The principal fungus disease not mentioned in last year's report, which deserves much study and which should be carefully guarded against in all the orange plantations of the island, is the Florida leaf-spot fungus (*Colletotrichum glœosporioides*). This fungus appeared during the last year in the station's citrus nursery, especially on rough lemon stock. It had been previously noted in several districts of the island, and it is doubtful whether this disease, which appears to be recently introduced, can be checked in its spread over the island. The peculiar root rot of the roselle (*Hibiscus sabdariffa*) attacked a few of the plants of this species. It is said to be common throughout Florida, and it appears to be of bacterial origin.

The exchange of seeds and plants with other stations in the Tropics has become a very important part of the station's work.

REPORT OF THE HORTICULTURIST.

By H. C. Henricksen.

Horticulture is yet in its infancy here, and it has been found necessary to do much pioneer work of a practical nature in order to form a basis for more scientific work. This has been especially difficult on account of the unskilled help, which has made it necessary for the horticulturist to attend to practical details which could and properly should be left to the gardener. It is hoped that it may be possible to secure the services of a trained man within a short time.

The climatic conditions of Porto Rico are such that results can be obtained in much shorter time than is required in the Temperate Zone. This is especially true when experimenting with annuals, but even perennials yield quick results. While this is an advantage in time saved it must not be imagined that it is work saved; on the contrary, it often requires the work of three or four years condensed into one. On that account it has been found necessary to take up one line of work and carry it through to a finish, or, as far as practicable, leaving other work in such shape that it can be developed at the first opportunity.

This year more than half the time was devoted to vegetable growing, on which subject a bulletin has been published. The experiments with pineapples are well forwarded and will be made the main subject for the coming year, after which the propagation of the mango and avocado should be far enough advanced to take the lead. Work on citrus culture has naturally required considerable time and no doubt will for a number of years, though with the addition of an entomologist and a plant pathologist to the station staff the horticultural side of this work will be reduced.

CITRUS FRUITS.

The growers who started orange groves in Porto Rico three to five years ago followed the methods prevailing in Florida and California, and the general results have been unsatisfactory, but the experience gained is invaluable. This report, giving a brief statement of the experiments at this station, as well as field notes obtained when visiting groves in all parts of the island, is intended to serve as a guide for the beginner, with the hope that it will carry him over many of the old pitfalls.

THE OLD METHOD.

In planting an orange tree by the usual method of trimming many of the roots and a corresponding number of branches and leaves, the tree is severely checked, especially if it is shipped some distance. If the weather is not very favorable the top is liable to die back more or less after planting, and it will be some time before the new growth starts. If the grove is exposed to high winds this new growth will be forced in one direction, giving the tree a lopsided appearance which is difficult to overcome. This is not the worst feature, however, but the high wind and hot sun retard the growth of the tree. If the tree is planted in uncultivated ground with just a hoed circle around and not well fertilized, which is often the case, the growth is sure to be anything but rapid. If, then, May beetles and the orange leaf-weevil begin to eat the foliage, which they often do, the tree will have made but little growth the first six months after planting.

The nursery trees are seldom entirely free from the purple scale, and as this pest increases rapidly, especially when the tree is not in a vigorous growing condition, the consequence is that, six to eight months after planting, the tree will be covered with scales before the grower realizes what to do. Spraying is the next thing; but a continuous spraying with mixtures strong enough to kill the purple scale is sure to cause injury to the half-starved, wind-swept, scale-sapped tree. If, after spraying, the trees are not thoroughly worked and fertilized, they will soon be beyond recovery and stand as scarecrows for the would-be orange grove.

If, on the other hand, the trees are well cared for, new growth will start from close above the union. This, if trained and kept free from scale, will form the new tree, and the old scaly stub may well be cut off as soon as possible, as it seldom makes much growth and it always serves as a breeding and distributing place for scale. But after all the efforts of the grower about two years of labor and expense has been lost. Of course, this is the dark side of the situation, nevertheless it shows exactly the conditions as they appear in many of the first-planted groves.

THE NEW METHOD.

All of these obstacles can be overcome by using methods which readily suggest themselves to the observant grower. The first and certainly the most important factor is shade and wind protection. The land should be cleared, well worked, and the rows laid out, after which a row of bananas should alternate with each row of trees. In about six months the bananas will be large enough to afford protection.

Plants like the pigeon pea (native name, gandula) or castor bean may also serve as temporary protection, but the first named is undesirable, because it harbors insects like the may beetles and orange leaf-weevil and the other is subject to scale of various kinds. In planting bananas it should be remembered that this plant is a gross feeder and will rob the orange trees if not checked. In order to do this a deep furrow should be plowed on each side about 4 feet from the banana row, and this operation should be repeated at least three or four times a year. The banana suckers should be thinned out and not allowed to spread too far. The yield of fruit may be found to be of considerable value, and in four to five years the plants may be taken out or left in the soil for fertilizer. The holes for the orange tree should be dug not less than 2 feet deep and 3 to 4 feet in diameter. The top soil should be filled in in alternate layers with dry grass, manure, or any other available organic material, together with 1 to 2 pounds of commercial fertilizer, preferably in organic form like tankage, blood and bone, dried blood, or native guano mixed with tobacco stems. The fertilizer should be well mixed with the upper layers of soil. The trees may be planted by the old method, but much better success can be obtained by planting with a ball of earth.

If the nursery is well fertilized and cultivated, the budded tree will be large enough for transplanting eight to ten months from budding or fourteen to sixteen months from seed. The nursery tree should be trained to stake in order to make a straight trunk and made to branch when not over 3 feet high. The branching should be carefully attended to because the early branches will, with this method, form the tree. When ready for transplanting, a trench should be dug around the tree at a distance of not less than 1½ feet from the trunk and deep enough to go below the lateral roots. The ball of earth inclosing the roots can be loosened by cutting the taproot with a spade. Two men will be able to lift the ball while the third slips a piece of burlap underneath. This may then be tied, so as to inclose the whole ball, which can be lifted onto a wagon and transported any distance without breaking. Of course this can be done only where the soil contains enough clay to prevent the ball from breaking.

The cost of this method of planting was ascertained at the grove of Graham & Co., Pueblo Viejo, but as the men were just being trained in it, it is probable that the figures can be reduced about 5 cents.

Cost of transplanting tree with ball of earth.

	Cents.
Digging hole 40 by 40 by 24 inches deep	3
Refilling holes and mixing soil with fertilizer	2
Digging tree with ball of earth 2½ to 3 feet in diameter	8
Carting one-half mile or less	3
Setting tree and watering	3
Total	19

This is probably 10 cents more expensive per tree than the old method, but it readily repays the extra cost, because when a clean tree is planted there will be but little spraying to do and at least one year's time is saved in the growth of the tree.

CULTIVATING AND FERTILIZING.

It has been the practice with many of the growers to leave the whole field in weeds and hoe a circle around each tree. This has not given the best results, because in hoeing the soil is not loosened and pulverized. In other groves the method of cultivating strips around the trees and leaving the middles uncultivated has been practiced. While this is an almost ideal way to enrich the soil if the middles are planted with legumes and plowed once or twice a year, it has not been wholly successful here, because any growth of grass or weeds serves as feeding and hiding places for the May beetle, orange leaf-weevil, and ants. It has been found necessary in many groves to keep the soil perfectly clean by going through it often with tools like disk and drag harrows and tooth cultivators. If this method is followed part of the year, it is not a good practice to let the weeds grow tall enough to necessitate the use of a turn plow, because that implement will destroy many roots and probably check the growth of the tree and lessen its vitality.

In fertilizing, most of the growers apply a small amount three to four times a year, which of course is good practice, but the amount is generally too small. This is an offhand statement, as no experiments have so far been made in fertilizing the orange trees in Porto Rico, but the groves which have received a large amount of fertilizer are certainly far ahead of those which have received less. As to the amount and kind of fertilizers, the question seems to be limited to how much the tree will take up. Large applications of nitrogen in organic forms have not so far been followed by die-back; in fact, die-back has not yet been observed on the island and there seems to be no danger on that point.

INSECT PESTS.

Numerous experiments for combating the chief diseases and insects have been conducted by the horticulturist as well as by individual orange growers throughout the last year. In order to fully describe these it would require more space than would be desirable in this report; furthermore, it is questionable whether it would be necessary. It is firmly believed by the horticulturist and by many of the growers that the present impediments to orange growing in Porto Rico are merely trifling troubles which can largely be overcome by intelligent planting and cultivation.

The purple scale (*Lepidosaphes beckii* Newm.).—In studying the problem of combating this pest it was found that on a few trees in the station orchard which were well protected from wind and sun the scale was kept in check by three species of fungi. An attempt was made to disseminate these through the grove, but it was not successful; evidently the conditions were unfavorable. Trees in natural groves, which are protected from wind and sun and where the air is uniformly moist, are always free from scale, and several attempts to distribute scale through such trees have always resulted in failures. Practically the same results have been obtained in other groves, although after a tree has become literally covered with scale the fungi can not be relied upon even when conditions are made favorable to their growth. It should therefore be the aim to plant the shade first, and to set no tree which is not perfectly free from scale.

The orange snow scale (*Chionaspis citri* Comst.) nearly always follows a severe attack of the purple scale. It is difficult to overcome, because the trees are at that stage not generally in condition to withstand concentrated sprays. It is improbable that this scale will cause much damage if the purple scale is kept in check.

The red scale (*Chrysomphalus ficus* Ashm.) has gained a foothold in some of the groves, but it has been causing but little damage so far.

The orange leaf-weevil (*Exophtalmus spengleri*) and allied species is causing considerable damage in groves which are not given clean cultivation. Experiments made to destroy these pests with poisons have not yet been concluded. Arsenate of lead has given favorable results, but whether it is because of killing the insect or merely repelling it is not known yet. Clean culture, however, is the best remedy.

May beetles caused considerable damage in former years, but in groves which are now kept free from weeds they have almost disappeared. The greatest damage caused by these insects is by eating the foliage; it is also universally believed that the larvæ feed on the bark of the roots. It is questionable whether much damage is caused in that way, but unquestionable evidence has been found in a few instances.

The brown ant which was reported upon last year by the entomologist of this station is not causing much damage at present. It occasionally eats the young foliage, which causes no severe injury to a vigorous tree. It very seldom injures mature bark except close to the ground. The injury there is caused by the ants building galleries of earth upon the trunk for some distance, which softens the bark underneath and makes it easy to puncture. The ants may live in those galleries for some time without puncturing the bark, but if left undisturbed for a long time they usually do so. The greatest damage is caused to trees which are affected with "gumming;" in fact, trees over two or three years old are seldom seriously damaged unless affected with that trouble. The remedy for ants is, in the first place, clean culture, by which means the nests are continually disturbed except close to the tree. For killing all the ants in a nest, nothing is better than carbon bisulphid, but that can not be used close to the tree, neither can it be used successfully in loose soil except when the soil contains enough moisture to make it impervious to the fumes. Any soap or emulsion used for scale is also a successful remedy for ants. Whale-oil soap or resin soap may be used as thick as it can be made to flow through the galleries, and it can be made more effective by adding crude carbolic acid at the rate of one part to ten of the soap solution. This can be used close to the tree without injury.

DISEASES.

With our present knowledge this subject must be treated with some caution, since many symptoms are ascribed to diseases which as a matter of fact are caused by some physiological derangement.

"Gumming" or "gum disease" occurs very frequently in some groves. When appearing on the limbs or upper part of the trunk it resembles psorosis, a disease known as "tears," from the fact that the gum often oozes through the bark in single drops. When appearing on the trunk above the collar roots it resembles foot rot or *mal-di-gomma* in some respects, while it is wholly dissimilar in other respects. The symptoms are exudation of gum, bark becoming brown in spots, frequently extending all around the trunk, and a watery, somewhat gummy substance under the bark which is without perceptible odor. The cambium layer or inner bark is not destroyed, and the tree is able to recuperate. The disease has in no case been observed to extend below the soil or on the main roots. It has been observed on sweet orange, lemon, grape fruit, and sour orange, although not often on the latter. This disease is often described as being of a bacterial origin and contagious. While it is no doubt safest to treat it as such, the indications are that the causes are physiological. It has been found on all classes of soil, but it is much more prevalent on the heavier soils than on those which consist mainly of sand. It is also frequently found in the rainy season, while in the dry season the trees have been known to overcome it entirely. It has been observed frequently on trees less than two years old and not so often on trees over three. It appears that an oversupply of moisture is the usual cause, and probably an oversupply of plant food tends to aggravate the disease.

Gum disease has often been confounded with the effect of an attack by ants, because ants usually follow and greatly aggravate the case. Several remedies have been tried, among which are tar and girdle paint, the latter made according to directions given in Circular No. 4 of this station. Both of these are good if the diseased bark is first cut away and the material painted over the open sore only. Cases have been observed where these mixtures were applied without removing the diseased bark, and the disease continued under the bark without interruption. Also where the mixtures were applied all around the trunk the effect would be the same as a tight bandage, which could be detected twelve to eighteen months after the application was made. A thick soap mixture containing about five parts of crude carbolic acid is now being used successfully. It covers the sores and acts as an antiseptic as well as a repellant for ants.

Leaf spot caused by a fungus (*Colletotrichum glœosporioides*) is found on the grape fruit in some groves, and these trees are also occasionally attacked by scab. Both of these can be checked with Bordeaux mixture or ammoniacal copper carbonate, but these mixtures should not be applied unless necessary, because they also kill the fungus parasites of the scale.

THE PRESENT OUTLOOK.

The question of growing an orange tree in Porto Rico so as to obtain the maximum result at minimum expense can be expressed with the one word "experience." . Groves three to four years old, which have been intelligently treated, are looking very promising and some are bearing considerable fruit of good quality. As to the most desirable varieties it is impossible to state definitely at the present time. Grape fruit is extensively planted and is very vigorous as well as prolific. The tangerine is also promising in that respect. The lemon also seems promising, and the Sicily varieties are being planted by some parties. Citron growing is very encouraging, the Corsica attaining a large size and good quality. It is not so well known as the other citrus fruits, and this station has therefore planted 200 trees in order to demonstrate the possibility of this industry.

PINEAPPLES.

The station pinery now contains twenty-six varieties, most of which will bear this year. All of the varieties are remarkably healthy and so far very vigorous. An attempt was made to fertilize some of the plats, but those experiments were discontinued because the conditions were such that the results would have been of little or no value. The experiments will be continued this year in a near-by field with a uniform soil which has not been cultivated for many years.

Two of the plats in the pinery have been planted with *Pithecolobium saman*, which are growing vigorously. Several new plats are being planted with various shade plants which will be allowed to grow until large enough to shade the ground before the pines are planted.

Large areas are now being planted to pines in various sections of the island, and it has already been demonstrated that pines can be grown successfully in several districts, although much land is undoubtedly being planted which will give but poor results. It is very difficult to determine whether a soil is fit for pineapple growing or not, the only reliable test being to cultivate a small area as a trial. It should not be forgotten, however, that soils vary very much within a short distance, and the success in one corner of a 50 to 100 acre plat is no criterion for the whole field. In land about which there may be any question it is always safest to work the soil up in beds 6 to 7 feet wide. The Red Spanish can be planted four rows 18 by 18 inches in beds 6½ feet wide and the Cabezonas three rows 24 by 24 inches in beds 6 feet wide. This leaves 1 foot on each side of the outside rows, and if the paths are left 6 feet wide and excavated 6 to 12 inches deep, the top of the beds will be 1 to 2 feet higher than the bottom of the path, which will give ample drainage. Under those conditions the pineapple plant will thrive where otherwise it would fail.

In the fall of 1903 about 2 acres were planted at Rincon with the variety Cabezona. Those plants were reported to be diseased, and the field was visited in April, 1903, at the owner's request. The plants were found to be of normal size, but the color of the leaves was of a light red to pure wax white, about 50 per cent being entirely devoid of chlorophyl and less than 15 per cent showing green, the rest red, green, and white mixed. The field was located near the ocean, but in no way injured by salt water. The soil, which was a beach sand, had recently been cleared of its natural growth, consisting mainly of cocoanut, sea grape, coco plum, a few sour orange, and the usual tropical shore line plants. The top soil, which was of a very fine texture, almost dust like, was found to be only 18 to 24 inches deep underlaid with a hard formation of cemented sand particles. Moisture was present in an overabundance in the top stratum, indicating the imperviousness of the subsoil.

While it was fully believed that the physical condition of the soil was the chief cause of the trouble, the extreme white color of the leaves might indicate some chemical derangement, and experiments were started June 2 to demonstrate the effect of fertilizers. The field was divided into ten plats, of which No. 1 was planned to be drained with surface ditches, No. 4 received an application of native guano, No. 9 received iron sulphate, and No. 10 was left for check. The other six plats were fertilized with commercial fertilizer in various combinations, which was applied under the direction of the horticulturist, one plat also receiving a liberal amount of lime.

The field was again visited October 15 and it was found that the owner had failed to drain plat No. 1 as agreed. The plants in all the plats were practically unchanged in color, but 20 to 30 per cent were found to be rotting in the heart and the heart leaves falling out, leaving the outside whorls intact. This is often met with in water-soaked soil, and can sometimes be partly remedied by drainage and aerating. Unfortunately that part of this experiment was not carried out, but in all probability it would have been of no avail in this case. It is safe to say that the soil was physically unfit for pineapple growing.

The station pinery planted with Cabezonas in the fall of 1903 (Pl. III, fig. 2) yielded a crop which was far above the average for that variety in Porto Rico or in Florida. Fully 95 per cent of the plants bore fruit, none of which were much below 5 pounds and the majority ranged from 8 to 15 pounds. As the soil in which these were planted is essentially the same as the majority of upland soil in this vicinity, it would probably be safe to apply the following figures to a large field: Planted 24 by 24 inches in beds 6 feet wide, with paths 6 feet wide between, will give 5,445 plants per acre. Reckoning on a yield of 85 per cent of marketable fruit the first cutting, this would average 4,628 pines per acre. These pines grown at the station were experimented with in various ways, to demonstrate the keeping and shipping qualities. One barrel was packed May 5 and sent by coastwise boat to San Juan, where it was transferred to the steamship *Ponce*, which left that port May 9 for New York. A report blank was sent to the steward, asking him to open the barrel May 10 and remove one fruit every day and report on the condition. He reported as follows: May 10, 1 fruit fit for use, others too green, quality first-class. May 11, still green, not ripe enough for table. May 12, cut two and found them in first-class condition. May 13, about the same as yesterday. May 14, had one for lunch, first-class condition, no decay. May 21, after leaving New York for return trip to San Juan served last pine, which was in good condition. This barrel was stored with the ship's vegetables, not in cold storage.

June 3 two large boxes and one barrel were packed with pines wrapped in paper and packed in excelsior. These were bought by a private party to take to the States, but did not reach the railroad station in time to go as planned. They were then taken back and placed in a storeroom, where one box and the barrel was closely covered with several thicknesses of tarpaulin, making it almost air-tight and very hot, being in that respect similar to the hold of a ship. One box was left uncovered, making the condition similar to the hold when ventilated. June 12 the two boxes were unpacked and no difference could be detected in the covered and uncovered lot, except the first was much hotter to the touch than the other. Nearly all the fruit was well ripened and only one out of thirty-three was bruised. When cut open most of the fruit showed brownish spots, indicating decay, but it was impossible to find the entrance or connection of those spots with the surface of the fruit. The decay was not far enough progressed to seriously injure the quality, but it is evident that a short time longer would have been fatal. The fruit would have sold readily because the outside appearance was all that could be asked for, but the same difficulties in shipping Cabezonas from this end of the island have been reported by several parties, and this will be made one of the chief features of the coming season's work.

VEGETABLES.

The importance of vegetable growing was recognized by the early management of this station as evidenced by previous annual reports. The results of the former experiments, although largely negative, are not without interest, remembering that by making proper deductions a negative result is as valuable as a positive. The experiments conducted this past year were planned to determine if vegetables can be successfully grown in Porto Rico, and if not, why not. Plantings were made in May, July, September, and November, 1904, and January and March, 1905. All of the principal garden vegetables were planted in large enough quantities to make the results of practical value. A large number of varieties were tested and the principal diseases noted. Various places on the island have been visited by the horticulturist who has noted the growth and behavior of vegetables under different environments, and obtained numerous reports from practical growers. This has been fully treated in a bulletin of the station. Some of the points which may be emphasized are: Most of the common garden vegetables can be grown successfully in most localities; vegetables can be planted any time of the year, with generally best success in the winter season. This is not so much on account of the difference in temperature as that the excessive rains in the summer make the cultivation difficult. In the drier localities splendid results are obtained by irrigation.

Although vegetable growing in the Tropics is in many respects similar to that in the Temperate Zone, some experience is necessary in order to make market gardening or truck farming a success.

The usual truck crops of the South can be profitably grown in Porto Rico for the northern market, some localities being more favorable than others for certain crops. But by knowing the requirements of the desired crop and choosing the right locality success is reasonably certain.

The diseases and insect pest are practically the same as those of the southern part of the United States.

MANGOES.

Mangoes have been experimented with in odd moments throughout the year, but on account of pressure of other work and lack of skilled help it has been impossible to devote much time to them. Large trees have been top budded, using various methods. It was found difficult to make a union and even more difficult to force the buds. Much valuable information has been obtained, however, as a guidance for further work.

Nineteen inarched trees have been received from the U. S. Department of Agriculture. Some of these were inarched into large trees and some into 2-year-old stock, after which they were planted in the orchard. The trees in the orchard, which are now 2 years old, from seed average 6½ feet high with a spread of 4½ feet. (Pl. IV, fig. 1.)

Ten thousand seeds were planted in a nursery this summer. These were brought in by boys and paid for at the rate of 50 cents per 1,000. A large percentage did not germinate. Those which did germinate were subject to a fungus disease which destroyed more than 50 per cent. One thousand seeds were soaked in a solution of copper sulphate (1 pound to 50 gallons water) for twelve hours and were then planted in a seed bed, which had formerly been used for a vegetable seed bed. Eighty to 90 per cent of the seeds germinated, but in less than two weeks the plants began to die off. Both the plants and the soil were sprayed with Bordeaux mixture every week, but very few plants survived. This disease is not destructive to plants after reaching the size of a lead pencil, and it does comparatively little damage in sandy soil free from vegetable matter. In Florida the trouble was overcome by using pure sea sand in the germinating bed, which has also been found entirely satisfactory here, but the plants should not be transplanted until the wood is well matured. This seedling disease is very destructive and very few volunteer seedlings survive. There are certain places on the island, however, where seedlings are plentiful under the large trees, and there it would probably not be difficult to grow a nursery.

AVOCADOS.

The 2-year-old trees in the miscellaneous orchard average 11 feet high with a spread of 7 feet. (Pl. IV, fig. 2.) Fifty more have been planted and a nursery containing about 1,000 plants has been started.

RUBBER.

The condition of the rubber trees is very much as in the last report. The Central American rubber trees (*Castilloa elastica*) which have been planted three years in very rich soil are now 16 feet high with a spread of 12 feet (Pl. V, fig. 1), while the others planted in the usual heavy clay soil are only 4 to 6 feet high. Trees which were sent to Arecibo and Bayamon have made growth similar to the best of these when on cultivated and fertilized soil. Some of the trees in the station plantation have been fertilized with stable manure, without perceptible change in growth and the result so far is negative. The experiments have brought out the following facts which correspond with the experience of the horticulturist in Florida. The Castilloa succeeds best when not transplanted or when transplanted very young, so as not to disturb the roots. A tree six to twelve months old is severely stunted by transplanting. The methods of planting in sod and keeping a small circle clean around the trees has not proved successful, except in soil which would have grown any other tropical tree under the same conditions. *Hevea braziliensis* has made but slow growth. *Manihot glaziovii* has made a fairly good growth near San Juan, where a few trees are planted in a yard. It is of course cultivated and probably fertilized. Small seedlings in the station nursery have been attacked by the cassava bud-maggot, which, however, does not damage larger trees.

MISCELLANEOUS PLANTS.

The following report does not include all of the plants under experiment by the horticultural department. Many have been omitted because it was thought that the conditions under which they were planted and the care received afterwards were wholly unsuitable. The same may be said about some of those reported upon, because a field test made here can not be taken as a criterion for the whole island. The chief aim of these experiments is to secure data for a report upon plants which may be of economic interest. This will bring them to

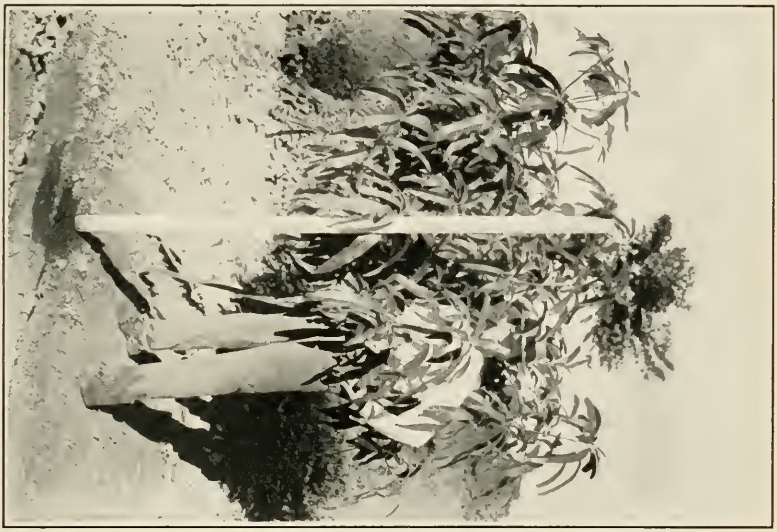

FIG. 1.—MANGO TREE TWO YEARS FROM SEED.

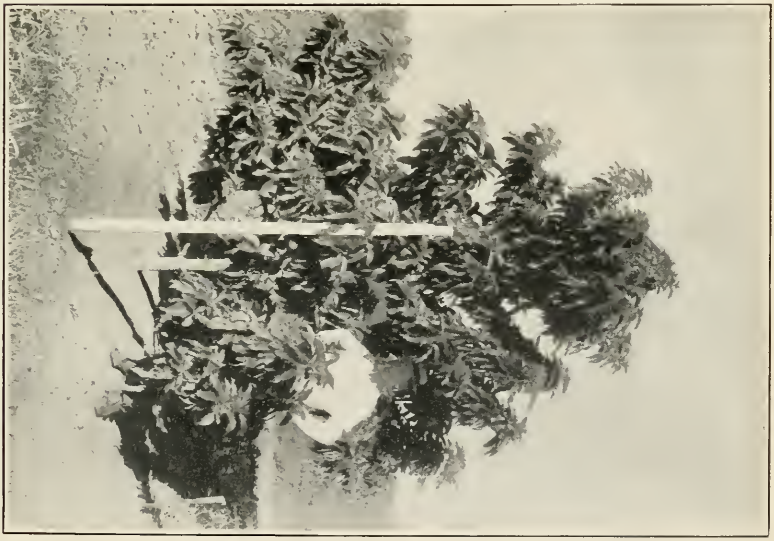

FIG. 2.—AVOCADO TWO YEARS FROM SEED.

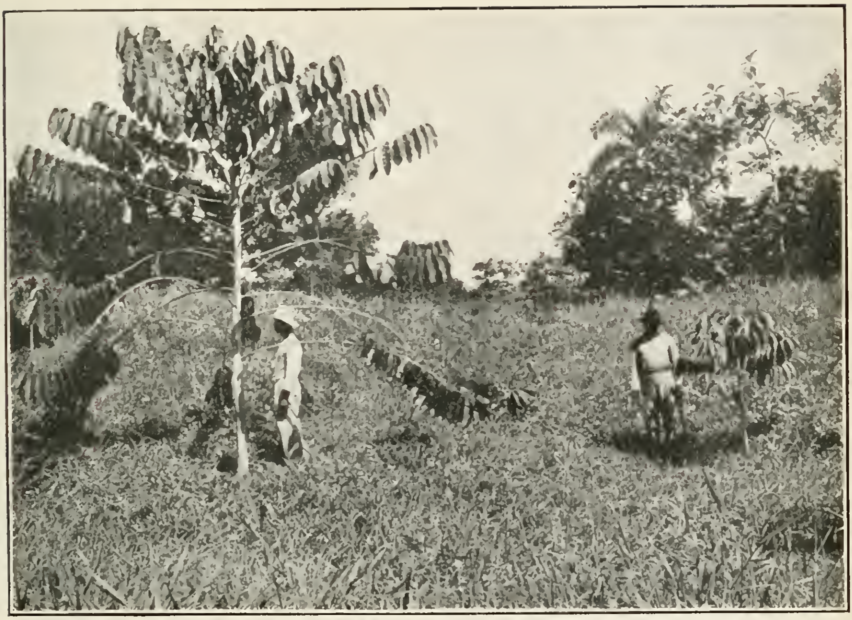

FIG. 1.—CASTILLOA RUBBER TREES OF SAME AGE IN FERTILE LOAM AND HEAVY CLAY SOIL.

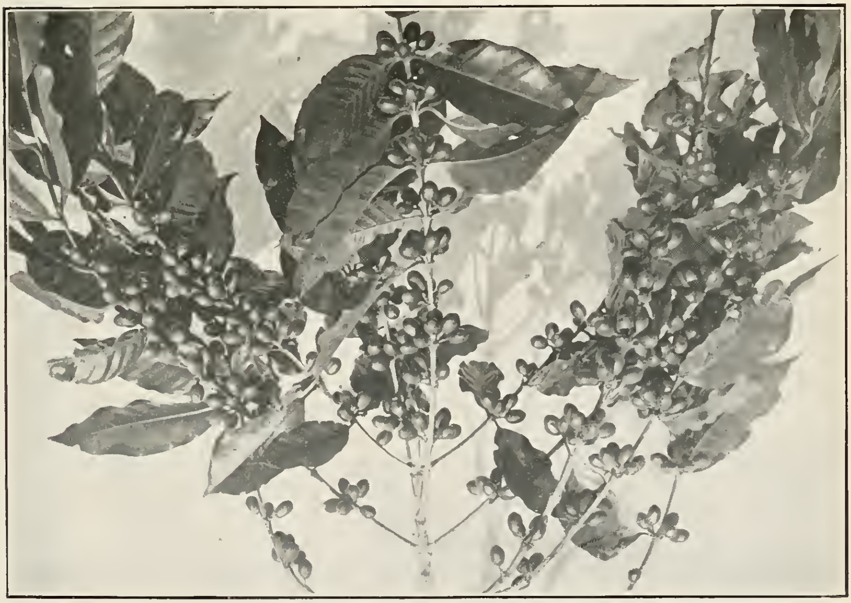

FIG. 2.—WELL-FILLED BRANCH OF COFFEE.

the attention of the planters, a number of whom are always glad to cooperate with the station. After a plant has been tried in the various locations it will be possible to make an intelligent and full report.

KEI APPLE (*Aberia caffra*).—Planted small plants September, 1903; present height, 6 feet; spread, 7 feet; plants healthy; have not fruited, but elsewhere fruit reported to be of fair quality. Promising as a hedge plant for Porto Rico.

SAPODILLA (*Achras sapota*).—This is commonly grown in Porto Rico, but it is of slow growth while young. Two-year-old plants in the orchard are only 2 feet high. It is a promising market fruit, and it can be grown successfully in the drier sections of the island.

CANDLENUT (*Aleuritis moluccana* and *A. cordata*).—The first mentioned is found more or less frequently on the island and is a fairly quick-growing tree. The latter was secured from the U. S. Department of Agriculture and planted in July, 1904. It is a tree of South Chinese origin and ought to thrive here, but it has been reported as a practical failure from all over the island. It would have been a valuable acquisition, as it yields an excellent lac varnish.

CASHEW (*Anacardium occidentale*).—This is a tree commonly grown in Porto Rico. The fruit is edible and liked by the natives, but of questionable market value. Trees planted September, 1903, are now 7 feet high, with a spread of 5 feet.

CHERIMOYA (*Anona cherimolia*).—This is one of the best of all the anonas and highly prized for its luscious fruit. Small plants set in the orchard September, 1903, are now 6 feet high, with a spread of 6 feet.

The sweet sop, sour sop, and custard apple (*Anona squamosa*, *A. muricata*, and *A. reticulata*) are grown all over the island. *A. squamosa* is usually called cherimolia here, but the two should not be confounded, as they are quite distinct. Of the trees planted in the orchard two years since, the *A. muricata* is the most vigorous—height, 11 feet; spread, 5 feet.

POND APPLE (*Anona glabra*).—Planted September, 1903; present height, 12 feet; spread, 11 feet; prolific bearer, but fruit of no commercial value.

APPLE.—The Early Harvest and Red Astrachan varieties were received from Florida and planted March, 1905. Both have made satisfactory growth, although the leaves have been diseased.

BREADFRUIT (*Artocarpus* sp.).—Both the seed-bearing and seedless varieties are found all over the island. The trees are quick growing, but succeed best when not transplanted. The seedless variety is propagated from cuttings. Trees in orchard planted from cuttings October, 1903, are now 9 feet high, with a spread of 5 feet.

JACK FRUIT (*Artocarpus integrifolia*).—This is highly recommended from India and Ceylon. Several trees have been planted in the orchard and are growing vigorously.

Carambola (*Averrhoa carambola*).—Seeds were obtained from St. Lucia and seedlings planted in the orchard February, 1904. These are making very slow growth.

Arnotto (*Bixa orellana*).—This plant producing the annatto coloring has not been of commercial value of late years, but inquiries have been received lately from firms in the United States, and there seems to be a possibility for the product commercially. The trees grow readily here, and bear a good crop in eighteen to twenty-four months from planting. Trees planted in the orchard September, 1903, are now in bearing.

Tropical papaw (*Carica papaya*) grows to perfection in all parts of the island, but *C. quercifolia*, a more hardy species, has invariably failed.

Amatungula (*Carissa arduina*).—One plant of this spiny shrub was planted August, 1903, and is now bearing fruit. The fruit is of pink color, subacid, not unlike a small plum without the pit. It is well worth extensive planting for home use.

Divi-divi (*Cæsalpinia coriaria*).—This leguminous tree, the pods of which are rich in tannin, is making satisfactory growth, and it seems probable that it may be of commercial importance in Porto Rico, if planted in large enough quantities.

Tea (*Camellia thea*).—None of the four varieties planted in July, 1903, has so far made satisfactory growth. Plants have been distributed to other parts of the island, but it is yet too early to report on these.

Star apple (*Chrysophyllum cainito*).—Two varieties of this are commonly grown on the island. Both were planted in the orchard September, 1903, and the trees are now 7 feet high, with a spread of 7 feet. Although the fruit is of fair quality, it is not probable that it will become of commercial value.

Cocoa plum (*Chrysobolanus icaco*).—This is one of the common shore-line plants, which bears prolifically in the beach sand without any care. It is not dependent on that environment, however, as it grows readily in the orchard. The fruit is often used for preserves and the plant is an acquisition to the home garden.

Camphor (*Cinnamomum camphora*).—The camphor tree is not promising in this vicinity. Larger trees have been observed in sandy soil, but none that would indicate a profitable industry.

Cinnamon (*Cinnamomum cassia*).—The cinnamon of commerce is *C. zeylanicum*. This species is said to yield a good bark, however, and it seems to be promising here, one tree in the orchard being 11 feet high, with a spread of 7 feet.

Cocoanut (*Cocos nucifera*).—There are no large areas planted with cocoanuts in Porto Rico, but it is always present in the shore-line flora wherever the conditions are favorable. The cocoanuts of Porto Rico rank among the best in the world's market, and although the industry is not so very extensive, it is of no mean importance to the island. No serious disease has been noted, and it is very important that the bacterial heart rot should not be introduced.

A disease was investigated in the summer of 1905 which appeared on the trunk as black spots, evidently caused by an outflow of sap. After splitting the trunk, these spots were found to extend about half way to the center and 6 to 8 inches vertically, with the softer portions decayed and the individual fibers exposed. Several spots would be found close together, but seldom connected. A small borer beetle, not determined, but probably a species of Xyleborus, was thought to be the primary cause, as a large number of those insects were entering the trunk of individual trees. Such trees first drop some leaves and then the fruit and the rest of the leaves, and finally die. The insect enters chiefly at a height of 6 to 8 feet. It is repelled by a coating of thick whitewash, and it would be well to whitewash the trunk of all the trees as high as practicable. Where the insects are numerous an addition of crude carbolic acid would probably be beneficial.

AKEE (*Cupania sapida*).—Some trees in the orchard are vigorous and healthy, indicating that the tree can be grown here. The fruit is highly prized in Jamaica and Trinidad and it ought to be grown in Porto Rico for home use.

TURMERIC (*Curcuma longa*).—This plant grows in most clay soils without the least care; in fact, it is one of the worst weeds in some localities. The root contains a yellow dye which has been largely replaced commercially by aniline dyes, but as there has been some inquiries about the plant lately it may possibly be of some importance.

JAPAN PERSIMMON (*Diospyros kaki*).—The varieties, Hyakume, Hachy Okame, Tana-Nashi, and Yeddo-ichi were planted in April, 1905. The growth has not been satisfactory and the leaves are affected with some fungus disease. Trees have been observed on the north side of the island, in sandy soil, which were in no better condition.

LOQUAT (*Eriobotrya japonica*).—Some trees set in the orchard a few months only are making rapid growth, but as no large trees have been observed on the island it would be impossible to judge of its adaptability. It should always be planted in well-drained soil and not cultivated too deeply, as it is a surface feeder.

ROSE APPLE (*Eugenia jambos*).—This is thoroughly at home here and can be grown all over the island.

JAVA PLUM (*Eugenia jambolana*).—One tree planted September, 1903, is now 5½ feet high with a spread of 4 feet.

SURINAM CHERRY (*Eugenia mitchelii*).—This small bush, bearing a red cherry-like fruit, grows well in south Florida and will probably succeed well here. The two-year-old plants in the orchard have not yet borne fruit.

OTAHEITE APPLE (*Eugenia malaccensis*).—Two-year-old trees in the orchard are now 10 feet high with a spread of 6 feet.

COCA or COCAINE PLANT (*Erythroxylum coca*).—Plants have been tried repeatedly in the orchard, but they always bloom and bear fruit when a few inches high, after which they die. One bush 6 feet high, the usual size of the plant, has been observed in a yard in the city of Mayaguez, indicating that it can be grown here under favorable conditions.

FIG (*Ficus carica*).—Many varieties have been tried at the station, but all have failed. No fig tree has yet been observed in Porto Rico to indicate that figs can be grown successfully. Experiments are under way to graft onto *F. oppositifolia* and *F. glomerata*, which, if successful, will make a more vigorous plant. A leaf disease occurring uniformly on all the fig trees observed here can probably be kept in check with Bordeaux mixture.

MANGOSTEEN (*Garcinia mangostana*).—This fruit, considered by many to be the most delicious in the world, is now being experimented with at this station. The tree is of very slow growth while young and the plants at the station are small yet. *G. indica*, an allied species to the *G. mangostana*, is growing in the orchard. Seeds were obtained in Trinidad, and the seedlings planted March, 1903. Present height, 4 feet; spread, 3 feet.

GENIPAP or JAGUA (*Genipa americana*).—This grows wild in most parts of the island. The fruit is eaten by the natives, but not commonly by foreigners. It is of no commercial value.

ROSELLE (*Hibiscus sabdariffa*).—This plant, which is often called Jamaica sorrel, is becoming prominent as a jelly plant (Pl. VI, fig. 2). It can be successfully grown in all classes of soil, although a sandy loam is preferable. Two plats about one-eighth of an acre each were planted at this station in March. These plants began to ripen fruit in September and continued fruiting until December. One plat, on low ground which was flooded several times throughout the season, did not produce much fruit. Plants on well-drained soil produced 4 pounds of fruit per plant, averaging 2 pounds of calyx, the useful part. Plants observed at Pueblo Viejo, in sandy loam, were estimated to yield double that amount. To prepare the fruit the calyx should be separated from the seed capsules. The latter may be fed to hogs and goats. The seeds are also good poultry feed. The calyx can be made into jelly in the usual way, like cranberries, which the jelly resembles very much. It can also be boiled with an equal amount of water, squeezed through a colander, and filled into bottles, which may then be sterilized in hot water and corked for future use. Sugar and yeast may also be added to this, when it is said to make a very good substitute for root beer. The calyx can also be air-dried or dried in a fruit evaporator, in which condition it will keep for a long time. The fresh fruit either with or without the seed capsule will keep for at least two weeks and may be shipped to the States in well-ventilated crates. It is firmly believed that this fruit will be of considerable value when introduced in the United States. The rich red color and acidity should make it a popular article for soda-water fountains. It would also be well adapted for mixing with other jelly fruits for color and acidity, where artificial preparations are forbidden or undesirable. The stems are reported to contain a fiber equal to jute. This has not been tested here, but it is well worth considering at the present price of fiber. This plant succeeds best when not transplanted, and it is therefore better to lay off rows 5 by 5 feet and drop a few seeds in each check. The seeds germinate quickly, but the first few months the plants do not grow very rapidly. After the plants are well developed all but one in each hill should be removed, and the soil should be kept clean until the growth makes cultivation impracticable.

BARBADOS CHERRY (*Malpighia glabra*).—This tree grows readily here and fruits at an early age. Two-year-old trees in the orchard are 5 feet high with a spread of 5 feet and bore fruit this year. The fruit is very good for jellies and desserts.

MAMME APPLE (*Mammea americana*).—This grows readily all over the island. Two-year-old trees in the orchard are 4½ feet high and well branched, from which it will be seen that it is not of rapid growth the first years. The fruit is eaten in jam by the natives and to some extent by foreigners. The tree is a prolific bearer, and if the fruit could be utilized commercially it would be of some importance to the island.

SPANISH LIME OF GINEP (*Melicocoa bijuga*).—This grows readily here, although not very fast. The fruit is eaten, but it will probably never be of importance commercially.

CERIMAN (*Monstera deliciosa*).—This aroid bearing a delicious fruit is not found in Porto Rico, but a few cuttings were recently distributed by the U. S. Department of Agriculture, and those received by this station are growing well. The plant succeeds best in a rather moist, half-shady situation, planted close to the trunk of a tree, or better, an old stump. These conditions can, of course, be found nearly anywhere in Porto Rico, and the plant is well worth extensive cultivation.

BANANA (*Musa* sp.).—The botanical collection at the station comprises seventy varieties. The best of these are being planted in order to test them horticulturally.

MULBERRY (*Morus alba*).—The three varieties, English, French, and Chinese, have been planted in the orchard a few months only, but the trees have made a growth of 7 to 9 feet in height and 4 to 6 feet in spread, the French being the more vigorous. One variety obtained on the island has been growing in the orchard for more than a year.

It is not as vigorous as the other three, but is very promising. Vigorous trees in other places have been observed, indicating the possibility of silk culture, which is actually being tried.

DOWNY MYRTLE (*Myrtus tomentosus*).—This is a shrub of Indian origin, bearing a very delicious fruit. One 2-year-old plant in the orchard bore fruit this year, and it can be thoroughly recommended for home use. It will probably not be a good shipper.

NUTMEG (*Myristica moschata*).—This is one of the species producing the nutmeg of commerce. One tree planted in the orchard September, 1903, is now 9 feet high with a spread of 7 feet.

PEAR.—The varieties Le Conte and Keiffer were planted in April, 1905, the trees having made a fair growth.

PEACH.—Six to twelve plants each of the following varieties were planted in the orchard in April, 1905: Angel, Bidwell Early, Bidwell Late, Jewel, Japan Dwarf Blood, Peen-To, Red Ceylon, and Waldo. These have made a growth of 6 feet high with a spread of 3 feet, as in the Bidwell Late, to 9 feet high with a spread of 6 feet, as in the Waldo and Red Ceylon. Six trees, comprising three different varieties, died early in the summer, from what was probably an overabundance of moisture at the roots, as it occurred in places not well drained. A fungus disease on the leaves has also caused some damage. Peach trees have been observed in other localities, but only a few planted in dooryards, and these were not very promising after the first year. Judging from the first year's growth, it seems probable that peaches may be produced here, but extensive planting can not be recommended until the termination of experiments now under way.

PLUM.—The following varieties budded on Marianna stock were received from a Florida nursery and planted in April, 1905: Terrell, Excelsior, Red June, Abundance, Burbank, and Wickson. These have made a fair growth, the Excelsior being in the lead with a height of 8 feet and a spread of 6 feet.

MYROBOLAN (*Phyllanthus emblica*).—One plant in the orchard, set December, 1903, is now 16 feet high with a spread of 9 feet. It is a beautiful ornamental plant and the fruit is reported to be of fair quality.

OTAHEITE GOOSEBERRY (*Phyllanthus disticha*).—This tree is thoroughly at home here, two-year-old trees being 12 feet high with a spread of 10 feet and bearing fruit this season. It is valuable for dooryard planting, the tree being ornamental as well as very prolific, producing an abundance of acid fruit useful for preserves.

GUAVA (*Psidium* sp.).—The Porto Rican guavas are very inferior in quality and the fruit is usually attacked with a disease causing them to shrivel up and blacken when about half grown. The varieties introduced from Florida are seldom attacked and plants in the orchard produced magnificent fruit this year. The collection includes *Psid-*

ium guajava, *P. molle*, *P. guineense*, *P. friedrichsthalianum*, and *P. cattleyanum*. These species are represented by numerous varieties, all of which succeed well here except the cattleyanums, which are subject to the shrinking or mummy disease referred to above.

MOUNTAIN PLUM (*Rheedia edulis*).—This is a slow-growing tree related to the mangosteen. One plant in the orchard is making satisfactory, although slow, growth.

TAMARIND (*Tamarindus indica*).—Both a sweet and an acid variety are found semi-wild in most parts of the island. Two-year-old trees in the orchard are now 7 feet high with a spread of 7 feet. It is not improbable that a market could be created in the United States for this fruit, and if so Porto Rico would be able to supply any reasonable demand. The tree succeeds well on the very driest portions of the island as well as where it is very wet, although it does not produce so much fruit in the latter localities.

CACAO (*Theobroma cacao*).—This is not produced in commercial quantities on the island, although a few trees are often grown for home use. Nine varieties from Trinidad, together with two commonly grown here, were planted in June, 1903, in a thickly forested valley. The natural growth has been cut out from time to time and cuttings of *Erythrina micropteryx* and *Gliricidia maculata* have been planted. The first named is far superior to the other; two-year-old trees from cuttings are now 15 feet high and well branched. The cacao is growing well, the trees being 5 to 10 feet high according to location. This method of planting is very successful and serves to illustrate the difference between this and the rubber reported upon (p. 34). In this case the natural growth was left and the soil is kept moist and in good condition, while in the valley where the rubber was planted the natural growth had been cleared off and the soil was in very poor condition for tree growth.

It may be mentioned that where the cacao is well shaded it is very healthy, while if the larger proportion of shade is suddenly removed the leaves die off and the tree is checked in growth.

VOA-VANGA (*Vangueria edulis*).—Seeds were obtained in Trinidad and seedlings planted in the orchard in March, 1903. These trees are now 7 feet high with a spread of 8 feet. The fruit is reported as being worthy of cultivation, but ours have not yet fruited.

VANILLA (*Vanilla planifolia*).—This is not cultivated commerically in Porto Rico. A few plants have been reported from various places, but the writer has never had the opportunity to inspect them. In corresponding with persons who desire to plant vanilla the advice has always been given to be careful in importing cuttings, so as to avoid the introduction of the vanilla disease of some of the other West Indian islands.

REPORT OF THE COFFEE SPECIALIST.

By J. W. van Leenhoff.

The investigations with coffee have been continued under the agreement mentioned in previous reports.

In those parts of the Tropics where the climate is especially agreeable to the North American or European, coffee, as a rule, grows best. This condition prevails in a high degree in the mountain districts of Porto Rico; no finer climate can be found in the world. The temperature ranges between 60 to 85° F., and while during the rainy season, September to December, rain falls continuously up to 20 inches per month and the weather conditions are less pleasant, yet this is outweighed by the weather conditions of the eight remaining, and especially the first four, months of the year. The total rainfall for the year is 100 to 120 inches.

Coffee can be profitably grown on nearly all kinds of soils, provided they do not retain water. The mechanical conditions of the soil are to be considered before the chemical composition. Virgin forest soil is the best, and it can still be had at about $10 per acre.

Up to a few years ago the cultivation of coffee was generally conducted in a very primitive way. Since that time, however, the establishment of a coffee experiment station has brought about more modern practices—as, for example, the introduction of seed and nursery beds, which are now found everywhere in the important Ponce and Utuado coffee districts where a few years ago only volunteer plants were used.

There has been a pronounced improvement in the coffee industry of Porto Rico. The crop for the season of 1905 is much larger and there has been an appreciable advance in prices. The insular government has established a commercial agency in New York for the purpose of introducing the Porto Rican coffee to the best trade in the States and also to serve without cost as a selling agency for our planters.

A kind of bitter taste and, possibly, weaker strength were given as reasons preventing the introduction of our coffee into the markets of the United States at remunerative prices, as the first-class trade there is accustomed to the fine Java coffees. In those countries of Europe where a large and fine looking bean is appreciated, our first-grade coffee finds a good market. These markets demand a large, clean, green bean, polished and colored, which latter processing has caused much complaint in the United States.

The larger part of last year's crop of the experiment station sold at 13 cents per pound delivered in Ponce for shipment to European markets. Second grades were shipped in large quantities to Cuba at a price of about 10½ cents per pound, this being due to the favorable tariff conditions with that country.

In order to obtain the highest prices for our coffee in the United States we must be able to compete with the fine grades of Java coffee, and with this end in view the coffee experiment station is now growing fine coffees from all parts of the world. Samples of these and the result of their crossbreeding will be sent to the United States market, and after due consideration of their different qualities, selections will be made and the planting of the selected varieties recommended to our coffee growers, and if possible seeds or seedlings will be placed at their disposal. At the same time, experiments are under way to increase the production per acre, which now averages about 350 pounds as against far larger outputs in other countries.

The interior of Porto Rico seems peculiarly adapted to producing the finer grades of coffee, and it would seem that those varieties that bring the top prices in the United States are the kinds toward which we should turn our attention. To grow such coffees would mean a very material increase in the prices received. In this connection the station is experimenting with different methods for increasing the yield and improving the quality of the product. This work is not only along the lines of better cultural methods, but tests methods of pruning, kinds and amounts of fertilizer, crossbreeding, etc.

The coffee experiments consist of: (1) Introduction of new varieties, of which groves of the following have been planted: Abeokuta from St. Lucia, Alta Verapaz from Guatemala, Haitian, Harrar from Abyssinia, hybrids from Ceylon, Kona from Hawaii, Liberia from Java, Maragogype from Java, Maragogype from Guatemala, Mauritius from Java, Menado from Celebes, Multiple Seed from Porto Rico, Padang from Sumatra, Philippinean, Preanger from Java, Robusta from Java, Stenophylla from Java. Although among the foregoing several desirable ones will probably be found, they represent only a small number of the varieties of the world. It is recommended that steps be taken to secure a complete collection of the different high-grade coffees of other countries, so as to be able to determine the best for Porto Rican conditions.

(2) Selection of varieties of desirable quality for the market of the United States and distribution and reproduction of same. Some of the introduced varieties will bear their first crop during the coming year, and it is hoped that in a short time it will be possible to determine their quality when grown in Porto Rican soil. As soon as desirable selections can be made, coffee seeds or plants will be distributed in various sections of the island among representative planters.

(3) Improvement of Porto Rican coffee by different methods of cultivation and by crossbreeding with other desirable varieties. Up to the present 2,269 Porto Rican trees have been planted in seventeen

fields. All the plants are doing well, and some of them will give first berries this year, but not sufficient to be able to show results or permit of selection for future use. However, enough has been determined to show the profitableness of improved cultural methods. Some of the trees coming into bearing are yielding over 2 pounds per tree (Pl. VI, fig. 1), which is several fold above the average of Porto Rican coffee.

As predicted in the former report the crop of 1904 was a poor one, not alone in the quality of berries harvested, but also in the weight of marketable coffee obtained from the berries. The heavy blossoming and favorable weather conditions of this year promise far better results for the present crop (Pl. V, fig. 2).

The experimental work has now approached the end of the constructive period. All the land necessary in the immediate future has been put under cultivation and according to the growth of the young plants different experiments can be taken in hand, while in the old groves the experiments thus far begun have been continued and should show results in the coming crop.

EXPERIMENTS WITH NEW PLANTINGS.

About 20 acres of virgin forest land have now been cleared and laid out in 51 fields, 34 of which are assigned to experiments with coffee and 17 to experiments with economic plants which may prove of value to coffee growers (Pl. VII, fig. 1).

The cost per acre of preparing the land, planting with coffee, and cultivation for one year was as follows:

Felling forest and burning	$11.00
Lining in, distances 7 by 7 feet	2.00
Making 888 plant holes 2 by 2 by 2 feet, at $10 per M	8.88
Filling of 888 plant holes, at $10 per M	8.88
Seeds and nursery beds for 888 plants ready for planting	5.00
Planting, transporting, etc., at $10 per M	8.88
Shade-tree seedlings and planting	1.50
Two hoeings, 1 foot radius in a circle around the tree, at $5 per M each	8.88
Four weedings, at $1.50 per M each	5.32
Total cost of 888 plants, corresponding to 1 acre, at the end of first year	60.34

All figures given are for the locality of the substation, but may vary somewhat in other sections in the island.

IMPROVEMENT OF AN OLD COFFEE GROVE.

Experiments of previous years on the improvement of an old coffee grove was continued and the crop produced on each of the acre plats under experiment was again ascertained. The results, as shown by the crop of 1904, are as follows:

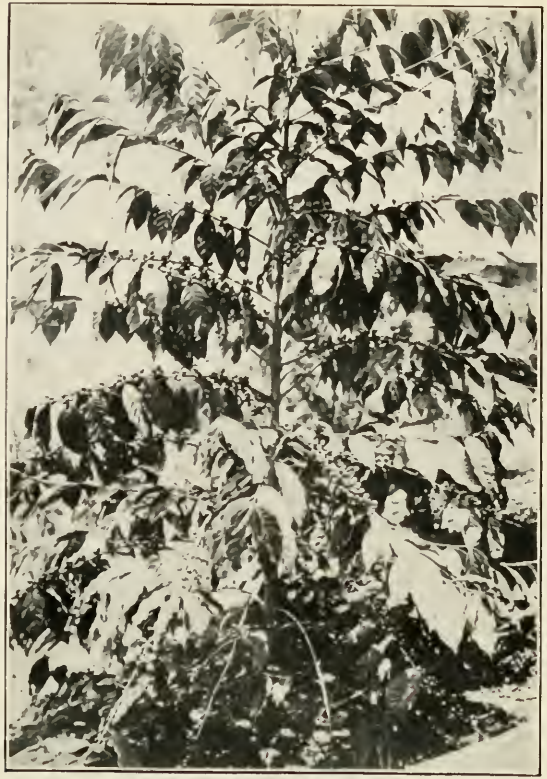

FIG. 1.—COFFEE IMPROVEMENT—2-YEAR-OLD TREE PRODUCED OVER 2 POUNDS OF COFFEE.

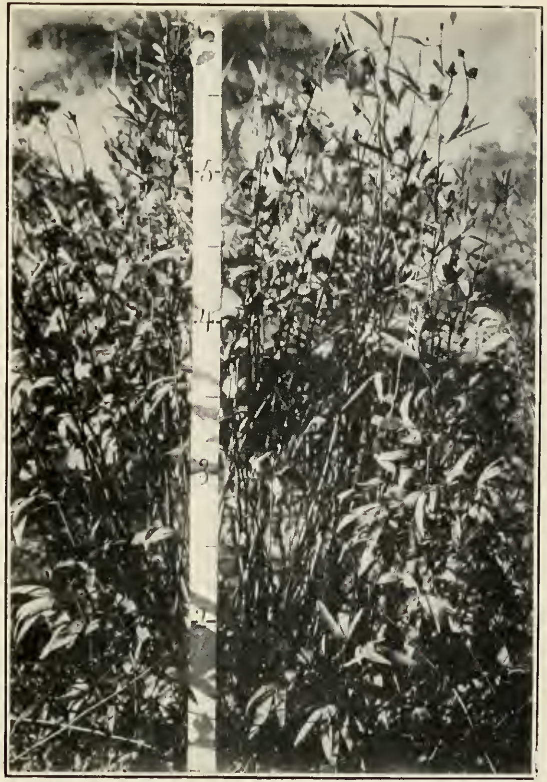

FIG. 2.—ROSELLE (HIBISCUS SABDARIFFA) IN FRUIT.

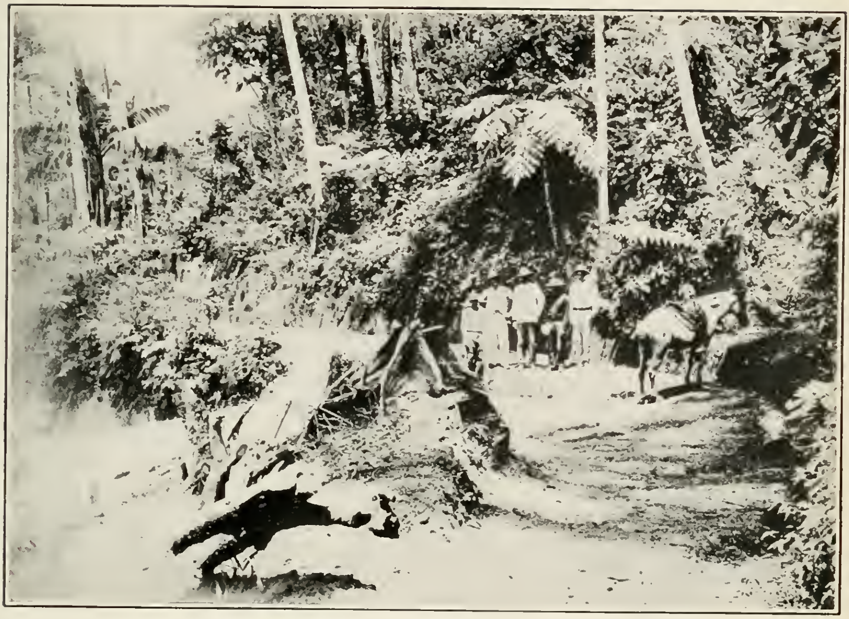

FIG. 1.—COFFEE SUBSTATION. ROAD MAKING IN NATURAL FOREST.

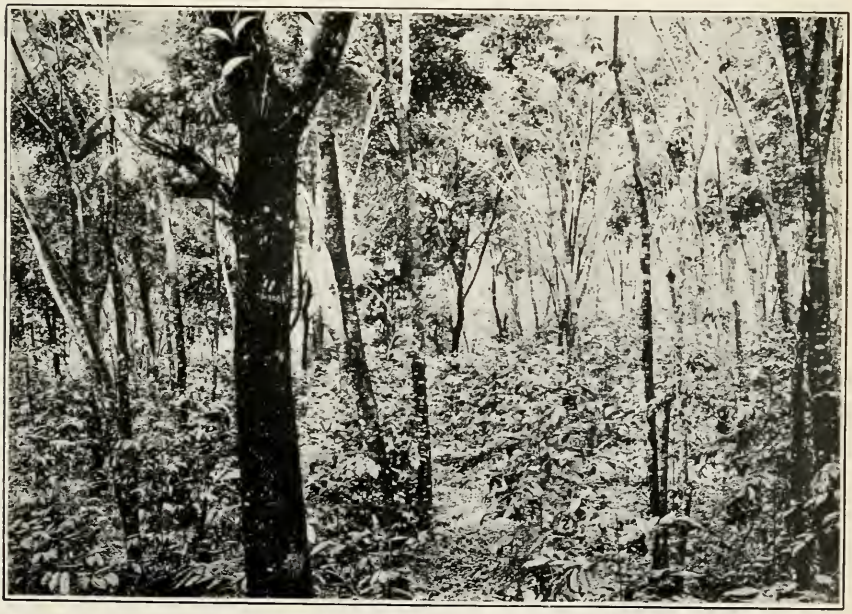

FIG. 2.—COFFEE SUBSTATION. TOO HEAVY SHADE.

Yield of coffee on experimental tract in 1904.

	Acre No.—									Total.	Average per acre.
	1.	2.	3.	4.	5.	6.	7.	9.	10.		
Ripe berries:											
In liters	738½	1,474	1,346½	904	83	113	93	137	41	4,930	547.7
In pounds	918½	1,892	1,756	1,195	114	148	126	188	61	6,398½	711
Coffee ready for market, in pounds	170	350	325	$221\frac{1}{10}$	$21\frac{1}{10}$	$27\frac{3}{10}$	$23\frac{3}{10}$	$34\frac{3}{10}$	$11\frac{3}{10}$	1,184	131.5
Productive trees per acre	413	1,095	882	742	428	745	584	902	924	6,715	746
Product per tree, in pounds	0.4116	0.32	0.3685	0.2979	0.0493	0.0366	0.04	0.0387	0.0122	1.5748	0.1755

Acre plats 1, 3, and 4 were divided into quarter-acre plats, each receiving different treatments. The yield of these plats is given in the following table:

Yield of coffee on quarter-acre plats.

Acre and plat.	Ripe berries.		Coffee ready for market.	Productive trees per plat.	Product per tree.
	Liters.	*Pounds.*	*Pounds.*	*Number.*	*Pounds.*
Acre No. 1:					
Plat No. 1	307	365.5	67.6	145	0.4662
Plat No. 2	291	376	69.6	104	.6692
Plat No. 3	140.5	177	32.8	85	.3859
Plat No. 4	0	0	0	79	....
Acre No. 3:					
Plat No. 5	854	1,108	205	389	.527
Plat No. 6	492.5	648	120	173	.6936
Plat No. 9	(a)	(a)	(a)	191	(b)
Plat No. 10	(a)	(a)	(a)	129	(b)
Acre No. 4:					
Plat No. 7	437	565	104.6	258	.4054
Plat No. 8	47	68	12.6	114	.1106
Plat No. 11	243	328	60.7	140	.4336
Plat No. 12	177	234	43.2	230	.188
Total	2,989	3,869.5	716.1	2,037	3.8795
Average per plat	299	387	71.6	170	.3515

[a] All coffee trees cut on stump.

[b] Not yet productive.

Total berries harvested, 4,930 liters=246½ almudes, which have given 1,184 pounds coffee ready for market, or 4.8 pounds per almude.

The low percentage of marketable coffee obtained in 1904 from the berries resulted in an increase of about 20 cents per 100 pounds in the cost for picking, making the total cost of harvesting and marketing per 100 pounds, $2.46. The cost of weeding and pruning the plantation during the year was $6 per acre, or $51 for 8½ acres, making the cost per 100 pounds, $4.30. Total paid for labor per 100 pounds, $6.76. The coffee sold consisted of 998 pounds of first grade at $13.12½ per 100 pounds, and 186 pounds of second grade at $10 and $11 per 100 pounds, or an average price of $11.37½ per 100 pounds.

Some experiments with fertilizers and leguminous crops on the coffee have been made, but because of the heavy rains, as stated in the former report, no results have been obtained that are reliable.

Acre No. 2, containing 1,095 trees, was fertilized December 8, 1903, with 950 pounds Porto Rico bat guano, and produced 350 pounds, as against 206 pounds in 1903, or an increase of 144 pounds.

Acre No. 3, which is situated on the slope immediately below acre No. 2, produced 325 pounds, as against 243 pounds in 1903, an increase of 82 pounds.

These are the only acre plats that, notwithstanding the unfavorable weather conditions, showed an increase of production, which might be attributed to the application of the bat guano in acre No. 2 and the supplying of plant food from the same to the lower lying No. 3 by rainwater. Bat guano can be had nearly all over the island.

Harvesting began October 13, 1904, and lasted until February 28, 1905, during which time eight pickings at different intervals had to be made.

Contrary to expectations, the two shoots remaining on each stump, and which have now developed into fair-sized trees, did not blossom to any extent this year.

The aspects of the two plats, Nos. 9 and 10, have now changed—that is, while before the shoots in No. 9 without shade grew quicker than those in No. 10 where the shade was left, it is now exactly the contrary, and in No. 10 the shoots look much better than in No. 9.

Plat No. 14, replanted with 164 coffee seedlings and the existing old shade left, is doing very well and the trees are growing nicely.

Plat No. 16, replanted with 190 coffee seedlings and all shade removed, is not doing so well; some of the seedlings have slowly developed, but others do not seem to prosper in the full sun.

Both these plats are situated at the lowest altitude of the grounds, and several hundred feet lower than No. 2.

Plat No. 15, planted to alfalfa, was reseeded with inoculated alfalfa seed, which came up well, but since does not continue to grow. Inspection of the roots did not show any root tubercles, and as a whole the plat does not look so promising as last year.

DISEASES AND INSECT PESTS.

Scale (*Saissetia hemisphærica* Targ.) is not so abundant as in former years, which may be due to various parasites.

Leaf weevils have done considerable damage, eating the leaves and young twigs and in some instances even ruining the young trees. It was noticed that in the neighborhood of Higuerillo trees the weevils were most abundant. Hand picking in the adult stage was resorted to with apparent success. In some places in the old plantations the weevils also attacked the small green coffee berries, but apparently to no great extent.

Leaf miners (*Leucoptera coffeella* Stain.) have increased enormously, and especially in the young coffee up to about 4 feet high. In many cases they were so abundant that the leaves died off, leaving the young coffee trees without any foliage whatever. In a neighboring plantation about 10 acres of young coffee trees are now almost entirely leafless. Hand picking has been tried, and in the month of May it was believed to have met with success, until a few weeks later a new and highly increased attack did away with all hopes to control the evil by hand picking. It is further observed that the better the soil the less the plants suffer from the attack. In the older plantations it seems that the parasites of the leaf miner, *Chrysocharis livida* Ashm., are sufficiently abundant to keep the evil under control. Artificial increase of the parasites might give very valuable results.

Some old coffee trees were observed on which the leaves had turned to a reddish color, followed by the trees dying. Leaves of such trees were sent to Washington for examination, where it was found to be a fungus, *Colletotrichum coffeanum*, probably appearing after an attack of leaf miner. The attacked trees had been already destroyed before information from Washington was received, and no remedies were tried.

In about 50 acres of heavily shaded old coffee (Pl. VII, fig. 2) near Juana Diaz a disease causing the kernels of the fruit to decay and turning the twigs black was found. Samples of attacked twigs and berries were also sent to Washington for investigation, but as yet the cause of the trouble is unknown.

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 172.

A. C. TRUE, Director.

IRRIGATION IN MONTANA.

BY

SAMUEL FORTIER,

ASSISTED BY

A. P. STOVER AND J. S. BAKER.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

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Bul. 119. Report of Irrigation Investigations for 1901, under the direction of Elwood Mead, chief. Pp. 401. (Separates only.)

Bul. 124. Report of Irrigation Investigations in Utah, under the direction of Elwood Mead, chief, assisted by R. P. Teele, A. P. Stover, A. F. Doremus, J. D. Stannard, Frank Adams, and G. L. Swendsen. Pp. 336.

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Bul. 131. Plans of Structures in use on Irrigation Canals in the United States, from drawings exhibited by the Office of Experiment Stations at Paris, in 1900, and at Buffalo, in 1901, prepared under the direction of Elwood Mead, chief. Pp. 51.

[Continued on third page of cover.]

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 172.

A. C. TRUE, Director.

IRRIGATION IN MONTANA.

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BY

SAMUEL FORTIER,

ASSISTED BY

A. P. STOVER AND J. S. BAKER.

1862 1889

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., February 20, 1906.

Sir: I have the honor to transmit herewith a report on Irrigation in Montana, prepared by Samuel Fortier, assisted by A. P. Stover and J. S. Baker, under the direction of Elwood Mead, Chief of Irrigation and Drainage Investigations.

In their study of conditions Professor Fortier and his assistants paid special attention to the means of bringing about the more economical use of the water supply, which would make possible the largest development of the State's agriculture. The most conspicuous sources of waste were poorly constructed ditches, poorly prepared fields, careless use, and lack of public supervision of the acquirement of rights and of the distribution of water. Owing to the large supply of water as compared with the present demand, there has been an indifference to these things, especially the need of legislation creating such public control as will insure the peaceable enjoyment of the rights to water, which is necessary to the highest development. In his conclusions Professor Fortier makes certain recommendations which, it is hoped, will help the people of Montana in securing such legislation. It is hoped also that the recommendations of Professor Fortier regarding improvements in the construction of ditches and in irrigation practice may lead to a more economical use of water.

It is therefore recommended that the report be published as a bulletin of this Office for circulation primarily in Montana, although its suggestions should be of value to the arid region generally.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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IRRIGATION IN MONTANA

In the early stages of agricultural development in Montana, as in the other arid States, the economical use of water was not important. The supply was large in proportion to the demand, and securing capital to build irrigation works, and methods of building ditches, preparing land, and applying water were the important matters. But those conditions are passing, and the State is entering upon the stage in which continued agricultural development will depend upon the economical use of its water supplies.

This report is based upon a study of the history of irrigation development and of present practice, made for the purpose of determining whether the existing methods and institutions will lead to the best use of water. The work included the study of irrigation practice in Gallatin and the Yellowstone valleys; seepage losses from ditches and methods of prevention throughout the State; volume of return seepage through streams in the Bitter Root Valley; and water-right records in the Gallatin Valley. It is believed that this study of typical localities gives a fair understanding of conditions throughout the State.

LAND AREAS.

As to the extent of land, every man, woman, and child now living in Montana might obtain a half section if its 93,000,000 acres were equally distributed. With the development of agriculture and the growth of population nearly every acre can be made to yield its tribute to the farmer. On the elevated ranges, with their snow-capped peaks and forest growth, it is hoped the fuel and lumber will be protected and conserved for succeeding generations. Here will also be found the natural storage reservoirs, which will yearly hold back the water for the farmers of the valleys. On the uplands which are too high to be reached by irrigation canals will be found the dry farms of winter-sown grains, while above these extend millions of acres of nutritious grasses.

On June 30, 1903, there were over 18,000,000 acres of Government land in the State open for occupation by individuals under the various laws. On the same date there was nearly 40,000,000 acres unsurveyed. These two items comprise nearly 65 per cent of the total land area. The area included in the forest reserves amounts to about 7,500,000 acres, and the six Indian reservations prior to the opening of a part of the Crow Reservation aggregated about 9,500,000 acres. In addition to the subdivisions named, there is the area appropriated, which has increased of late years by more than a million acres a year. In 1899 it was 13,000,000 and in 1905 it was 19,279,000 acres. A more exact statement, taken from the Report of the Commissioner of the General Land Office regarding the status of land in Montana on July 1, 1905, is herewith given:

	Acres.
Area surveyed and open for settlement	19, 241, 264
Area unsurveyed	36, 507, 106
Area reserved	18, 566, 188
Area appropriated	19, 279, 012

A considerable portion of the area appropriated has been purchased from the Northern Pacific Railroad Company. The grant to this company comprised about 15,000,000 acres, of which nearly one-half has been patented and sold to private parties. According to the Congressional Record of March 25, 1904, the public lands of Montana disposed of from July 1, 1881, to June 30, 1902, are as shown in the following statement:

	Acres.
Timber and stone lands	171, 977
Final desert entries	1, 284, 431
Commuted homesteads	383, 121
Final homesteads	1, 573, 777
State lands selected	961, 621
Railroad grants patented	6, 611, 083
Total in twenty-one years	10, 986, 010

Only about 10 per cent of the land that has been appropriated is farmed, and of this portion about two-thirds is irrigated. The total area irrigated in 1904 was probably 1,250,000 to 1,500,000 acres. It is from this comparatively small area that the greater part of the agricultural wealth, exclusive of stock interests, is derived, and from which a large part of the total revenues are raised. In 1902 the State board of equalization assessed 10,542,536 acres at $25,300,972, or $2.40 per acre. This average rate is low for the reason that unfenced grazing lands in that year were assessed at only 75 cents and railroad lands at 85 cents per acre. On the other hand, first-class grain lands under irrigation were occasionally assessed as high as $30 per acre. On an average, 1 acre of grain land is assessed as high as 10 acres of grazing land.

According to the census of 1902, 1,140,694 acres were irrigated in Montana. This was an increase of 18.1 per cent over the area irrigated in 1899. More land has been reclaimed during the two years that have followed than in the two that preceded that date, so that it is safe to assert that at the present time there are over 1,500,000 acres under irrigation. This large area, comprising 70 per cent of the farm homes and much of the choice lands of the State, yields an average return of about $25,000,000. Much of this is paid to the merchant for food and wearing apparel, to the manufacturer for farm implements, to the transportation companies in payment of freight charges, or to county and State in payment of taxes. It is thus apparent that this basic industry of irrigated agriculture is not only serving to develop the resources of a new State, but at the same time it is promoting the welfare of other important industries.

THE WATER SUPPLY.

For an arid State, Montana is well watered. Occupying as it does the crest of the continent, many rivers have their source and flow from its elevated ranges and mesas. Some of these streams have not as yet been utilized to any great extent for irrigation, and in consequence their water has little present value. Others are partially utilized, while still others have been wholly appropriated. However, only a few of the larger streams have ever been measured and little is known of the discharge of scores of the smaller rivers and creeks. The following summary of the annual discharge of some of the principal rivers in 1903, as determined by the engineers of the United States Geological Survey, may convey some idea of the extent of the water supply:

Discharge of Montana rivers, 1903.

	Acre-feet.
Yellowstone River at Livingston	2,654,000
Gallatin River at Logan	841,000
Madison River at Morris	1,265,000
Jefferson River at Sappington	1,872,000
Bitter Root River at Grantsdale	1,128,000
Missoula River at Missoula	2,459,000
Big Blackfoot River at Bonner	1,026,000
Marias River at Shelby	1,183,000
St. Mary River at International Line	1,213,000
Total[a]	13,641,000

The water supply for 1903 was about normal. On account, however, of the short irrigation season the full flow of streams can not be utilized without storage for more than a third of the year. It is true this growing period occurs at a time when the rivers are high, but even with this favorable condition it is not possible to utilize for irrigation purposes more than one-half of the total yearly flow. The data regarding the quantities of water which can be retained in the smaller streams are too limited and uncertain to enable one to estimate with any degree of accuracy the number of acres which can be irrigated from these sources. From a more or less intimate knowledge of the water resources of the State, the writer would place the limit at 6,000,000 acres as being the largest amount of land which can be irrigated in Montana from all sources, including stream flow, storage reservoirs, and wells.

---

[a] The Missouri River is not included for the reason that the greater part of its discharge is derived from the Gallatin, Madison, and Jefferson rivers.

It may be stated in a general way that for every acre that can be irrigated there will be nearly 2 acres that may be cultivated dry and 10 acres that will afford pasture for stock. How to make the best possible use of 6,000,000 acres of irrigable lands, of 10,000,000 acres of arable bench lands, and of 50,000,000 acres of grazing lands is the most vital and far-reaching question that is likely to arise in Montana for the next quarter of a century. It has always seemed to the writer that the ideal farm in this mountain State would consist of 40 acres of irrigated land with a good water right, about 40 to 80 acres of arable bench land, and about 640 acres of fenced grazing land on a near-by mountain slope.

CLIMATE.

The climate of Montana is arid and is typical of much of the Rocky Mountain region, but nearly 70 per cent of the average precipitation of 14.5 inches occurs during the crop-growing season. Few records have been taken to show the heavy precipitation on the mountain slopes. The officers of Fort Yellowstone, in the Yellowstone National Park, claim that the depth of snow varies from 10 feet in the neighborhood of Mammoth Hot Springs to 20 feet at the higher elevations within and adjacent to the park. The light snowfall in the valleys during the winter months is usually speedily evaporated by the chinook winds, which are met with from Oregon to Nebraska and from the Peace River to Arizona, and are particularly common in Montana, doing much to modify the climate. The effect of one of these dry, warm winds in raising the temperature and melting the snow is aptly described in the Montana Weather Report for December, 1896:

> On the evening of December 1, 1896, the temperature at Kipp, Mont., was —13° F. The air was scarcely moving and the sky was clear. Suddenly, over the edge of the mountains in the southwest appeared a great bank of black clouds, their outer edges blown into tatters by the wind. In a few minutes a short puff of hot, dry air had reached the plains, and in the following seven minutes the temperature rose 34°. The wind increased in velocity to 25 miles and the temperature rose to 38°. Within twelve hours every vestige of the 30 inches of snow had disappeared, leaving the hills bare and the plains covered with water.

While the temperature often reaches —40° F. at Havre, which lies in the direct path of the winter storms from the north and northwest, the lowest record at Missoula for twenty-three years is —22° F., and in some winters the mercury does not go below the zero point. In many parts of the State the spring months are the most disagreeable. March, April, and May are the worst, and the sunshine of June 1 is often obscured by showers of soft snow. But with two hundred and seventy-three sunshiny days and only ninety-two rainy days in the year, the Montana farmer receives with gratitude his allotment of June snow, because it benefits his crops and may save him the work of a second irrigation.

CROPS.

In response to a large number of circular letters which were sent out in the summer of 1904 from the Montana Experiment Station, the yields and value of the ordinary crops grown in the principal irrigated valleys of the States were obtained. The accompanying statement represents the averages of all the complete replies received to an inquiry sent to representative farmers regarding the principal crops in their neighborhood, the average yields per acre, and the prevailing prices for the past few years:

Crop returns in Montana.

Kind of crop.	Yield per acre.	Price.	Value.
Wheat	33 bushels	$1 per cwt	$20.16
Oats	57.90 bushels	$1.04 per cwt	19.27
Barley	56.50 bushels	$1.03 per cwt	25.24
Alfalfa	4.18 tons	$5.19 per ton	21.69
Timothy	1.46 tons	$9.43 per ton	13.77
Clover	3.67 tons	$5 per ton	18.35
Potatoes	200 bushels	50 cents per cwt	60.00
Deciduous fruits and berries			100.00

The yields with their corresponding values given in the table are considerably above the average of the irrigated portion of the State. In many parts both water and land are cheap, and careless methods of farming are practiced. The land is not properly cultivated and much of the water applied does more harm than good. Farmers seem to prefer to go to the expense and trouble of cultivating 100 acres in a slipshod manner for half a crop rather than to farm 50 acres in a skillful way for a full crop. The figures of crop yields, however, represent with a fair degree of accuracy what can be accomplished when care and skill are exercised in cultivating the soil and applying the water.

Nearly three-fourths of all the wheat and rye grown in the State are produced on dry farms. A large part of the oats and barley is also raised on dry farms, so that more than one-half of the entire cereal crop comes from the unirrigated farms. This branch of farming is increasing at a rapid rate. Plowed fields which at one time were confined to the lowlands are now found far up the mountain side, and it is safe to assert that in a very few years several million acres will be cultivated in this manner.

In developing this feature of its agricultural wealth, Montana is imitating the course pursued by California. The valley lands of the San Joaquin and Sacramento valleys have been producing grain for forty years without being irrigated. The soil in these valleys is of great depth and at one time gave heavy yields, but the continuous cropping of grain without rotation has reduced the yield until now many farmers consider themselves fortunate when the returns at the close of the season's operations show no loss. The bench lands of Montana are likely to fail to produce profitable yields at an earlier period, for the reason that the soil is less deep. Some kind of a simple rotation with a leguminous crop should be introduced, if possible. The rains in the spring are quite abundant as a rule, and if these should fail or prove inadequate, sufficient water can usually be had from the neighboring creeks to thoroughly wet the soil during the early spring or late autumn months, when such water is not used by those who irrigate in summer.

With sufficient moisture and a thoroughly prepared seed bed, it is believed that alfalfa can be successfully raised over much of the arable but nonirrigable lands. The yield would be, as a matter of course, much less than on properly irrigated land; one medium crop, and under favorable conditions two, would be the average yield; but the yield is of secondary importance. By a simple rotation of this kind the productive power of the soil could be maintained and the dry farms made to yield for an indefinite period. For at least six months every year water flows past hundreds of farms unutilized. Winter water in the Santa Clara Valley, California, is worth $2 to $5 per acre-foot, and the time will doubtless come when water will have a correspondingly high value in Montana. In this regard the vast acreage of fertile bench lands for which no water is to be had in summer affords a field for profitable investigations, not only in winter irrigation, but in the conservation of the natural rainfall by proper tillage and the introduction of leguminous crops to rotate with the cereals.

THE GALLATIN VALLEY.

Gallatin County, comprising a total area of 1,663,000 acres, is an irregularly shaped tract of land occupying the south-central part of the State of Montana. The southern portion of the county is mountainous and extends to the boundary of Idaho and the Yellowstone National Park; the land to the north is less elevated and affords fairly good range, while the middle portion of the county contains the rich alluvial plain known as Gallatin Valley. This valley is 28 miles long and about 14 miles wide. Around the upper rim the fall varies from 50 to 80 feet per mile, while from the Missouri River to Bozeman the average grade on the Northern Pacific Railroad is somewhat more than 30 feet per mile. The elevation of the railroad track at Bozeman, near the upper end of the valley, is 4,754 feet and at Logan, a small town located near the lower end of the valley and distant 24 miles, it is 4,032 feet. There is consequently a difference of 722 feet in elevation in 24 miles.

Gallatin Valley is for the most part surrounded by mountain ranges. To the south are to be found the sharp-pointed, snow-covered peaks of the Gallatin Mountains; on the east the steep incline from the East Gallatin River terminates in the Bridger Range, while a low range separates it from the valley of the upper Missouri River on the northwest and a plateau forms the divide between it and the Madison Valley on the west.

The people of Gallatin County paid taxes in 1902 on over half a million acres. This area was divided as follows:

Private land in Gallatin County, 1902.

	Acres.
First-class grain and hay land, most of which was irrigated	98, 115
Second-class grain and hay land	112, 910
Fenced grazing lands	205, 130
Unfenced grazing lands	73, 160
Railroad lands	58, 831
Total	548, 146

There were about 100,000 acres irrigated and about 110,000 acres cultivated dry in 1903. On an average 1 acre of irrigated land is as profitable as 3 or 4 acres of the same quality of nonirrigated land, for the reason that the former, under a proper rotation, will produce a crop every year while the latter has to be rested alternate years, the irrigated land producing also a greater diversity of crops.

In a general way the soils of the Gallatin Valley may be classed under two heads, viz, those derived directly from the disintegration of the materials of the Bozeman Lake beds and remaining in place and those formed by the sorting over of the above materials by the various streams of the valley. The first of these two classes constitutes the higher "bench" lands, while the other comprises the bottom lands bordering the streams or occupying the lower levels of the valley. These have much in common, yet there are also marked differences. Gravel is rarely found in the bench-land soil, while it is common in the bottom lands.

The thickness of the soil varies very greatly, averaging perhaps 12 inches, the subsoil averaging 2 feet, with usually gravel below. This is more particularly true of the bottom-land class. The soils are deeper and richer in humus in the upper end of the valley, whereas about the middle of the valley the gravel forms an extensive bar, reaching practically to the surface.

The following average of soils from the experiment station farm is typical of the better class of soils:

Average of soil of experiment farm.

	Per cent.
Coarse material	1.664
Fine earth	98.336
Analysis of fine earth:	
Insoluble matter	80.410
Soluble matter	19.590
Soluble silica	.130
Potash	.600
Soda	.360
Lime	1.160
Magnesia	1.150
Manganese oxid	.960
Peroxid of iron	3.920
Alumina	6.150
Phosphoric acid	.290
Sulphuric acid	.113
Organic matter	5.440
Moisture	4.080
Nitrogen	.170

The soils in general are loams with just the desirable proportion of sand to clay, so that on the one hand they are not too loose, while on the other they do not bake or offer obstacles to the free movement of crops.

Alkali is found in harmful quantity in only a few sections of limited extent.

CLIMATE.

The climatological records of the Montana Agricultural College cover only a few years, but this deficiency has been made up, in a large measure, by the painstaking labors of Mr. Peter Koch, of Bozeman, Mont. Mr. Koch began taking observations January 1, 1880, and continued them through a period of twenty years. Under the direction of the author a complete transcript of his records has been made into a permanent record book, to which have been added, from the college records, the data pertaining to the years from 1900 to 1902, inclusive. In the following paragraphs the results of Mr. Koch's records for twenty years, together with those of the additional years, are summarized.

From 1880 to 1902 the average rainfall at Bozeman has been a trifle more than 19 inches. Some portions of the cultivated area of Gallatin Valley have a greater precipitation, while other portions have less, the average for the entire valley being probably somewhat less than that of Bozeman. This precipitation is considerably more than that of the State as a whole. In this period there were a few dry years, notably 1889 and 1900, in both of which the precipitation fell below 15 inches.

This was chiefly due to the light snowfall, which in 1889 was only 1.5 inches in January, February, and March, and in 1900 3.24 inches during five of the winter months. The years of heavy precipitation were 1880 and 1892. In 1880 9.5 inches fell during the winter months of January, February, March, November, and December, and in 1892 8.5 inches in the same time. The yearly fluctuation of the fall of rain and snow from 1880 to 1901 is shown by figure 1.

In the monthly distribution of the precipitation, Gallatin Valley, and in fact the entire State, is highly favored. The greatest precipitation occurs during the months following seedtime (fig. 2). April, May, and June are the wettest months of the year. For the past twenty-two years the average precipitation for these months has been 1.99, 2.40, and 2.94 inches, respectively, or 7⅓ inches in all. This quantity of moisture, which falls either as rain or soft snow, is nearly all absorbed by the properly tilled soil and supplies moisture not only to bring the plant well above the surface but to bring it well along toward maturity. August is the driest month, averaging 0.67 inch. The average for July is 1.1 inches. This midsummer period of dry, sunshiny weather enables the farmer to harvest his crops in good condition and at the least expense.

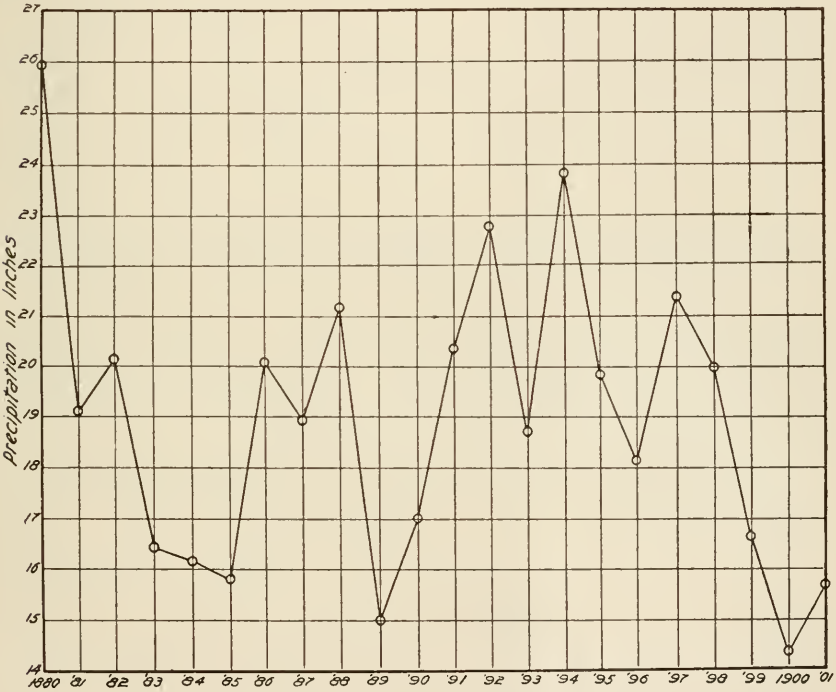

FIG. 1.—Total annual precipitation, Bozeman, Mont., 1880 to 1901.

The highest temperature at Bozeman during the past twenty-two years, as shown by Koch's records, is 100° F. The mean relative humidity of the Gallatin Valley is about 40 per cent. Only twice in twenty-two years has the mercury in the shade risen to 100° F. The average maximum temperature for that period is 93° F. Figure 3 shows the mean monthly temperatures from January 1, 1880, to January 1, 1902. The averages for June, July, August, and September are 57.1°, 63.8°, 65.7°, and 53.7°, respectively.

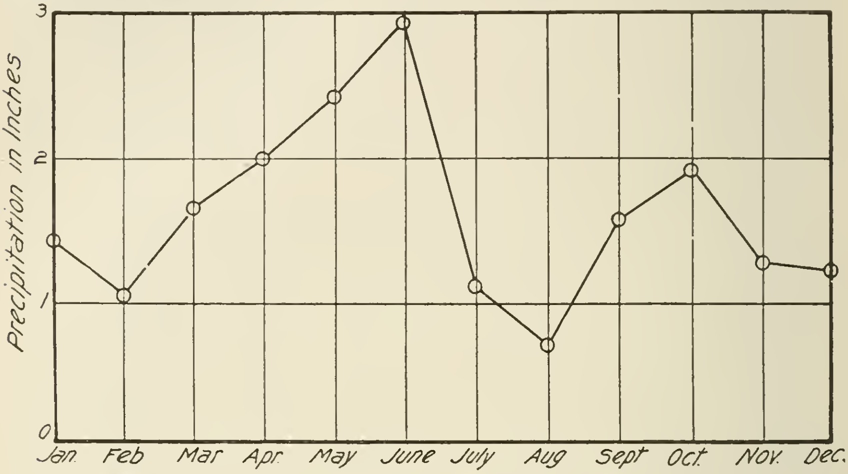

FIG. 2.—Mean monthly precipitation, Bozeman, Mont., January, 1880, to December, 1902.

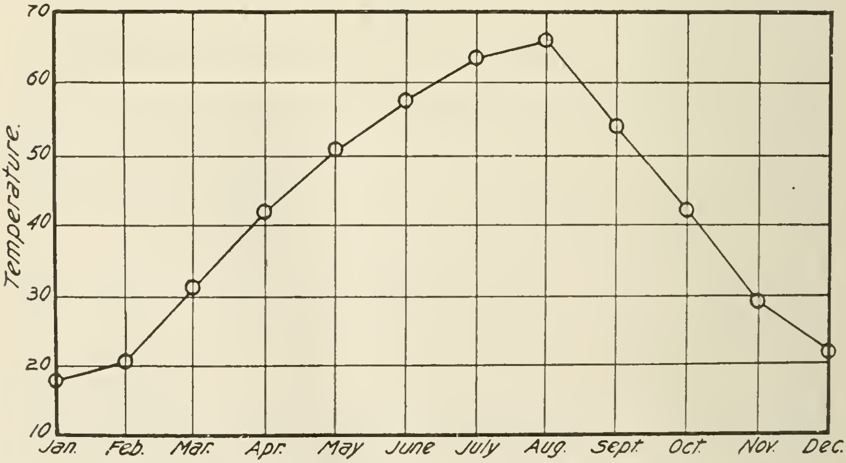

FIG. 3.—Mean monthly temperatures, Bozeman, Mont., 1880 to 1902.

The impression prevails in many States that the winter climate of Montana is very severe. This impression is not in accord with the mean monthly temperature records as indicated in figure 3 and given in the following table.

Average temperatures, 1880–1902.

	°F.
October	42.2
November	29.5
December	22.1
January	18.2
February	20.8
March	31.4

In the period under consideration there have been spells of intense cold. Five times in twenty-two years the mercury has gone below −40°, and on January 14, 1888, it registered −50°. On the other hand, the winter of 1901 was unusually mild and the lowest record was −14°.

The valley, for the most part being surrounded by mountains, is not subject to high winds. The lowest temperature is usually reached in a calm, clear night. The period of severe cold seldom lasts long. Rarely does the average minimum temperature for any winter month fall below zero, and on an average the temperature of 92.5 per cent of all the days in the year is above zero.

From the farmer's standpoint the worst feature of the climate is the comparatively short season between the late spring and the early autumn frosts. Frosts always occur in May and September. In ten out of the twenty-two years covered by the record there have been frosts in June; in one year there was frost in July, and in five years there were frosts in August. Of the frosts in June, July, and August 70 per cent have either been 2° or less of frost. Inasmuch as most plants can resist at least 1° below freezing it follows that the injurious effects of low temperature during the months named have not been great. Only once in twenty-two years has there been no frost in September. The September freeze may occur early in the month, in which case it occasionally injures late-sown wheat.

WEST GALLATIN RIVER.

This stream is by far the largest and most important tributary of the Gallatin drainage system. From its source in the northwest corner of the Yellowstone National Park it takes a northerly course in general, and for the first 65 miles of its course is confined to rough, mountainous country. At this point it leaves its canyon and enters the broad Gallatin Valley, through the western portion of which it takes a slight northwesterly course to the northern extremity of the valley, where it is joined by the East Gallatin River, flows westerly for a distance of 8 or 9 miles, and joins the Madison and Jefferson rivers at Three Forks, the three streams forming the upper Missouri River.

The drainage area of the West Gallatin River contains approximately 1,200 square miles. This area includes the basin of the river's valley tributaries in addition to that of the main stream itself. Of this 1,200 square miles, 876 square miles is tributary to the river above its point of entrance into Gallatin Valley. This rough, mountainous area lies at an elevation above sea level varying from 9,000 to 10,000 feet near Gallatin Lake in the Park to 5,200 feet at the mouth of West Gallatin Canyon. The greater part of this area lying below the timber line is covered with a heavy and luxuriant growth of forest and underbrush well calculated to conserve and protect the soil moisture, snowdrifts, and ice banks, from which the water supply of the river is drawn.

Like all mountain streams the West Gallatin derives its supply from a multitude of feeders and tributaries, both small and large, which head up in the mountains. In this discussion the West Gallatin tributaries have been divided into two classes, viz, the canyon tributaries and the valley tributaries.

The highest tributary of sufficient importance to be here considered is Taylors Fork or Dodge Creek, which enters from the west near the twenty-fifth mile of the river's course. As yet there is no irrigation from this creek, although during 1902 there were several filings made upon its waters. The land to be served lies along the creek bottom near the river. The elevation of the canyon in this vicinity is about 7,000 feet.

In the next 10 miles below Taylors Fork several fair-sized tributaries join the river. Among the important ones are Buffalo Horn, Cinnamon, Buck, and Elkhorn creeks. From only one of these streams, Buffalo Horn, is there any water diverted for irrigation. In 1899 a small ditch was taken out of this creek and with it about 200 acres of canyon land is said to be irrigated.

About 12 miles below Taylors Fork the river is joined from the east by Porcupine Creek and from the west near the same point by Beaver Creek. Some 3 miles below, West Fork, the largest tributary of the West Gallatin, enters from the west. The canyon, from a point a mile or so above Porcupine and Beaver creeks to the junction point of West Fork and the river, widens out and forms what is called the "Lower basin." This basin is about 3 miles long by 1 to 1.5 miles wide and is estimated to contain probably 2,000 acres of arable land, most of which could be irrigated. As yet there are but two small ditches taken out in the basin. One taps Porcupine Creek and serves about 200 acres of land on the east side of the river. The other takes its supply from West Fork and serves about 200 acres. Both of these are late ditches, the Waters ditch out of Porcupine Creek having been built in 1900, the Crail ditch out of West Fork being built in 1902. A ditch out of Beaver Creek is planned, construction to begin soon. This ditch is to serve about 1,000 or 1,200 acres of land lying on the west side of the river.

On leaving the lower basin the river again enters a narrow canyon and for 21 miles is confined by high mountain walls. All along the canyon course it is joined at short intervals by tributaries, both small and large. Near the lower end of the canyon it is joined from the east by Squaw Creek and from the west by Logger, Hell Roaring, and Spanish creeks. The last two creeks are among the important West Gallatin tributaries, Spanish Creek standing next in size to West Fork. In what is termed Spanish Creek Basin, lying along Spanish Creek and to the west of the West Gallatin Canyon, is a considerable area subject to cultivation. In this locality there are eight small ditches, varying in capacity from 50 to 300 miner's inches each, which tap Spanish Creek and distribute the water thus diverted to an area of land aggregating 2,000 acres. Some of these rights date back to 1885 and 1886; the majority, however, have been acquired in recent years.

About 2 miles below Spanish Creek the river leaves the canyon and enters the Gallatin Valley, in which lie the lands which utilize the greatest part of its flow during the irrigation season. The valley tributaries of the West Gallatin are Wilson, Bear, Cottonwood, and Camp creeks. The first three join the river from the east about 4 miles below the mouth of the canyon. The last is of little importance as an irrigation stream. It rises in the low hills which separate the Gallatin and Madison basins and flows in a southerly direction, joining the river just above the junction of the West and East Gallatin rivers.

During the irrigation season the entire flow of the three creeks entering from the east is diverted for irrigation purposes. The land they serve lies on the benches to the east of the river. Cottonwood is the largest of the three creeks, having a drainage area of 40 square miles.

The following table shows the discharge of these creeks on different dates during the irrigation season of 1902. It was impossible to obtain suitable places of measurement above all ditches, so they were measured at the mouths of their respective canyons and the flow of all ditches diverting waters above the points of measurement was added. In the table are also given the discharges of some of the canyon tributaries of the West Gallatin. These measurements were made during the period of high water. For the sake of comparison the results of two measurements of the river, made June 9 and 14 at Williams bridge, about 1 mile below the mouth of the canyon, are included in the table.

Discharge of West Gallatin tributaries, 1903.

Name of tributary.	Date of measurement.	Discharge.	
		Cubic feet per second.	Miner's inches.
Cottonwood Creek	June 3	128.02	5,120.8
Do	June 23	127.72	5,108.8
Do	July 10	64.48	2,579.2
Do	Aug. 13	32.63	1,305.2
Bear Creek	June 3	46.91	1,876.4
Do	June 23	27.50	1,100.0
Do	July 10	12.94	517.6
Do	July 13	7.07	282.8
Wilson Creek	June 3	22.18	887.2
Do	July 10	8.68	347.2
Do	Aug. 13	4.44	177.6
Spanish Creek	June 10	464.33	18,573.2
Do	July 17	163.59	6,543.6
Logger Creek	June 10	5.51	220.4
Hell Roaring Creek	....do...	306.76	12,270.4
Do	June 18	91.69	3,667.6
Squaw Creek	June 11	137.65	5,506.0
Swan Creek	....do...	142.70	5,708.0
Moose Creek	....do...	52.50	2.100.0
Portal Creek	....do...	160.00	6,400.0
Dudley Creek	....do...	77.96	3,118.4
West Fork	June 12	607.81	24,312.4
Waters ditch (Porcupine Creek)	....do...	1.78	71.2
West Gallatin River at Williams bridge	June 9	4,361.22	174,448.8
West Gallatin River	June 14	4,767.81	190,712.4

Like all mountain streams whose flow is derived from melting snows high up in the mountains, the West Gallatin is subject to a large flood flow during the spring season, estimated by the United States Geological Survey to reach in some years 4.5 times the average normal discharge.

Following is a summary of the observations made by the United States Geological Survey at Williams bridge for a period of six years, 1896 to 1901, inclusive:

Annual discharge of West Gallatin River at Williams bridge, 1896–1901.

Year.	Maximum.	Minimum.	Mean.	Total.	Run-off.	
					Depth.	Per square mile.
	Cu. ft. per sec.	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Acre-feet.*	*Inches.*	*Cu. ft. per sec.*
1896	10,750	100	1,132	817,824	17.66	1.31
1897	5,780	350	993	922,396	15.71	1.15
1898	7,226	560	1,328	961,231	20.96	1.55
1899	9,760	650	1,570	1,148,039	24.78	....
1900	5,410	280	991	718,260	15.67	1.15
1901	5,058	435	....	....	....	....

The actual minimum flow of the rivers for the years given above is somewhat greater than that noted, as five ditches head on the river above the gauging station. During the irrigation season the combined flow of those five canals would probably reach 120 or 125 cubic feet per second.

From the mouth of the canyon to a point on the river about 25 miles below the river has an average fall of 32 feet per mile, and its channel is subject to very little change. This makes tapping the river comparatively easy. In the 25 miles there are no less than fifty-four ditches taking water from the river. These ditches, especially those built some years ago, are for the most part small, having been built by the irrigators themselves, three, four, or half a dozen farmers joining in the construction of a common ditch. Most of the ditches of this class were built for the irrigation of lands lying contiguous to the river bottom, and little or no difficult work was encountered.

When the higher valley lands were settled several large canals were constructed which take their supply well up on the river.

USE OF WATER.

DIVERSION AND DISTRIBUTION.

Not in the history of irrigation from the West Gallatin has there ever been any regulation as to the extent of the diversions made because in normal seasons the river's supply has been sufficient to meet all demands. But during seasons of short supply, only one or two of which have as yet been experienced, the supply while sufficient, had proper division been made, was not equal to the demands, and on the lower part of the streams a severe shortage was felt, and a stage is being reached where the demand will more often exceed the supply and the old régime will have to give place to some system of stream control.

The methods of distributing water from the larger canals to consumers have not reached a settled state. On the West Gallatin Irrigation Company's two canals the amounts diverted by laterals are computed by a hydraulic formula. The factors necessary are, first, size of opening of the lateral head gate; second, head of water in canal over opening; and, third, the velocity of flow through opening, which is obtained for different heads from Trautwine's Engineering Handbook. The actual discharge is assumed to be 70 per cent of the theoretical discharge derived from the above factors. All discharge measurements are expressed in Montana inches.

On the Kleinschmidt canal, within the last year, the current meter has been adopted. Up to the time of its adoption the diversions by laterals were in the majority of cases left to the ditch rider, whose estimate of a lateral's discharge was accepted as the probable flow.

On the Farmers canal trapezoidal weirs have been constructed in the laterals near their points of diversion. But for want of proper care in their maintenance they are in the majority of cases in poor condition, and are but little better than no measuring device at all.

On the Kughen ditch and a majority of other larger ditches no system of measurement is employed, the amount diverted by the laterals being left to the discretion of the ditch walker or to the irrigators themselves.

On the smaller ditches taking water from the river, where only a few parties are interested, no measured division of the ditches' supply is made, each person taking an amount proportionate to his needs.

METHODS OF IRRIGATION.

The methods of applying water to crops irrigated from the West Gallatin are in every way similar to those employed in other sections of the State and are described in another part of this report. (See pp. 48–56.)

FLOW OF RIVER AND CANALS.

During the season of 1902, along with other field observations made in the Gallatin Basin, a series of measurements was made of all the canals and ditches taking water from the West Gallatin. One set of measurements was made during the middle of June at a time when a majority of the canals were diverting their greatest volume. This measurement was made some three or four weeks after the irrigation season had opened. A second set of measurements was made about the middle of July, and a third set of measurements was made about the middle of August. This last measurement represents the flow at the termination of the irrigation period. In the two tables which follow are given the results of these three sets of measurements. Those in the first table give the discharge of the canals on the east side of the river in the order in which they head on the river. The second table gives in a similar order the discharge of all canals on the west side of the river.

As the statute inch is used extensively in Montana in the statement of stream discharges, the values in the following tables have been expressed both in cubic feet per second and in Montana inches, 40 of which are equivalent to 1 cubic foot per second.

Discharge of canals on east side of West Gallatin River, 1902.

Name of canal.	June 14-20.		July 15-18.		August 14-16.		Mean flow for season.	
	Cubic feet per second.	Miner's inches.	Cubic feet per second.	Miner's inches.	Cubic feet per second.	Miner's inches	Cubic feet per second.	Miner's inches.
Kleinschmidt	79.27	3,170.8	101.81	4,072.4	98.01	3,920.4	96.03	3,841.2
Bush	7.28	291.2	15.24	609.6	4.43	177.2	9.89	395.6
Ralph	0.00	0.0	2.87	114.8	.89	35.6	2.21	88.4
Farmers, or Excelsior	168.22	6,728.8	193.46	7,738.4	116.11	4,641.4	167.89	6,715.6
Ferris	26.27	1,050.8	12.22	488.8	11.99	479.6	17.79	711.6
Middle Creek supply	58.85	2,354.0	39.94	1,597.6	35.53	1,421.2	46.60	1,861.0
Accola	6.29	251.6	3.72	148.8	0.00	0.0	5.00	200.0
Beck, Border, Spring & Matthews	12.90	483.6	32.00	1,280.0	10.78	431.2	19.79	791.6
Bicketts—Tudor & Nieble	5.16	206.4	4.35	174.0	1.59	63.6	4.12	164.8
Spain	28.37	1,131.8	31.18	1,259.2	8.70	348.0	25.68	1,027.2
Waterman	9.25	370.0	.33	13.2	5.83	233.2	4.99	199.6
Ketterer, Owenhouse & Stephens	43.49	1,739.6	18.39	735.6	14.60	584.0	27.67	1,106.8
Knadler, ½; Foerschler, ½	8.94	357.6	12.49	499.6	15.30	612.0	11.63	463.2
Stephens & Creasy	14.14	565.6	11.16	446.4	3.58	143.2	10.83	433.2
Weaver & McDonald	8.32	332.8	19.16	766.4	6.92	276.8	12.37	494.8
Knadler, White & Knadler	.75	30.0	.50	20.0	1.45	58.0	.79	31.6
Hoffman, Stephens & Cook	8.87	354.8	15.17	606.8	6.60	264.0	10.93	437.2
Weaver & Stone	4.79	191.6	.75	30.0	5.32	212.8	3.28	131.6
Learmouth, Ferguson, Patterson & Owenhouse	8.86	354.4	4.19	167.6	17.41	696.4	8.70	348.0
Hoffman & Marks	10.83	433.2	5.22	208.8	2.61	104.4	6.94	277.6
Bell, Franks & Creasy	11.04	441.6	2.10	84.0	1.79	71.6	5.61	224.4
Old Creamery or Cockrill ditch	9.54	381.6	5.92	236.8	1.78	71.2	6.54	261.6
Dawes Bros. & Porter	13.21	528.4	1.73	69.2	.75	30.0	6.12	244.8
Gibson & Green	.50	20.0	0.00	0.0	0.00	0.0	.50	20.0
Total	545.14	....	534.20	....	371.97	....	511.90	....

Discharge of canals on west side of West Gallatin River, 1902.

Name of canal.	June 14-20.		July 15-18.		August 14-16.		Mean flow for season.	
	Cubic feet per second.	Miner's inches.	Cubic feet per second.	Miner's inches.	Cubic feet per second.	Miner's inches.	Cubic feet per second.	Miner's inches.
Williams No. 1	....	....	5.09	203.6	1.78	71.2	3.99	159 6
Williams No. 2 (lower)	21.89	875.6	12.87	514.8	6.31	252.4	15.16	606.4
Cockrill	5.09	203.6	2.05	82.0	.50	20.0	2.95	118.0
Todd	....	....	3.10	124.0	1.38	55.2	1.51	60.4
West Gallatin (high line)	100.10	4,004.0	106.19	4,247.6	46.02	1,840.8	91.72	3,668.8
Sterling	8.56	342.4	3.52	140.8	7.59	303.6	6.35	254.0
Le Beau	20.68	827.1	8.09	323.6	.62	24.8	11.63	465.2
Railey	0.00	0.0	3.16	126.4	.30	12.0	2.21	88.4
Gabriel	1.69	67.6	2.49	99.6	3.35	134.0	2.34	93.6
West Gallatin (short line)	21.57	862.8	26.29	1,051.6	12.87	514.8	21.72	868.8
Cameron or Kughen	58.80	235.2	76.11	3,044.4	32.82	1,312.8	60.53	2,421.2
Cameron, Nieble, Corrie & Clark	16.89	675.6	15.96	639.4	3.67	146.7	13.87	554.8
Corrie	1.50	60.0	.30	12.0	.80	32.0	.88	35.2
Davidson, Leach, Smith & Heiskell	48.02	1,920.8	20.18	807.2	5.56	322.4	28.39	1,135.6
Lewis	31.73	1,269.0	8.43	337.4	17.05	682.0	19.45	778.8
Holgate & Grove	8.62	344.8	2.83	113.2	2.61	104.4	5.10	204.1
Holgate lateral No. 1	1.77	70.8	2.48	99.2	1.71	68.4	2.04	81.7
Holgate lateral No. 2	.40	16.0	0.00	0.0	1.88	75.2	.54	216.0
Manhattan or Moreland	23.05	922.0	11.87	474.8	23.14	925.6	18.59	743.6
Patterson & Boss	12.66	506.4	5.14	205.6	0.00	0.0	8.90	356.0
White or Cayuse	29.30	1,171.9	31.44	1,257.5	4.56	182.4	25.21	1,008.4
Buckley, Curtis & Holgate	10.49	419.6	8.30	332.0	5.20	208.0	8.55	342.0
Lamphear & Bryan	10.48	419.2	4.21	168.4	5.14	205.6	6.90	276.0
Heeb No. 1	3.33	133.2	1.20	48.0	5.76	230.4	2.96	118.4
Heeb No. 2	11.89	475.6	8 83	353.2	6.24	249.6	9.53	381.2
Heeb No. 3	1.75	70.0	1.35	54.0	.95	38.0	1.35	54.0
Cruse No. 1	1.00	40.0	6.11	244.4	3.05	122.0	3.45	138.0
Cruse No. 2	0.00	0.0	1.21	49.6	1.75	70.0	1.50	60.0
Lower Manhattan	22.20	888.0	22.65	906.0	0.00	0 0	22.42	896.8
Baker	8.33	333.2	4.11	165.6	1.68	67.2	5.32	212.8
Total	481.79	....	405.62	....	204.29	....	405.06	....

The values in the column headed "Mean flow for season" have been derived from the measurements given in the other columns. The measurements made in August, however, were given only one-half the weight of those made in June and July.

By cooperating with the representatives of the United States Geological Survey a daily record of the flow of the West Gallatin at Williams bridge for the months of the irrigation season was obtained. The flow of the river at this point in both cubic feet per second and Montana miner's inches is given in the following table:

Discharge of West Gallatin River at Williams bridge, Gallatin Valley, Montana, 1902.

Day of month.	May.		June.		July.		August.		September.	
	Cubic feet per second.	Miner's inches.	Cubic feet per second.	Miner's inches.	Cubic feet per second.	Miner's inches.	Cubic feet per second.	Miner's inches.	Cubic feet per second.	Miner's inches.
1	500	20,000	5,000	203,600	1,530	61,200	810	32,600	500	20,000
2	500	20,000	3,220	128,800	1,665	66,000	755	30,200	475	19,000
3	450	18,000	2,775	111,000	1,737	69,480	700	28,200	450	18,000
4	450	18,000	2,605	104,200	1,530	61,200	700	28,200	450	18,000
5	450	18,000	2,605	104,200	1,415	56,600	700	28,200	100	15,200
6	500	20,000	2,605	104,200	1,415	56,600	650	26,000	400	15,200
7	600	24,000	3,130	125,200	1,310	52,200	650	26,000	400	15,200
8	650	26,000	4,887	195,280	1,263	50,480	650	26,000	360	14,200
9	810	32,600	5,225	212,200	1,215	48,800	650	26,000	360	14,200
10	982	39,280	5,000	203,600	1,215	48,800	600	24,000	360	14,200
11	1,060	42,400	5,000	203,600	1,215	48,800	600	24,000	360	14,200
12	1,175	47,080	4,325	173,000	1,215	48,800	550	22,000	360	14,200
13	1,472	58,880	4,325	173,000	1,263	50,480	600	24,000	360	14,200
14	1,885	75,400	4,213	168,480	1,263	50,480	600	24,000	360	14,200
15	2,690	107,600	3,595	143,200	1,310	52,200	600	24,000	450	18,000
16	2,120	84,800	2,605	104,200	1,310	52,200	600	24,000	400	15,200
17	1,885	75,400	2,445	97,800	1,310	52,200	600	24,000	400	15,200
18	1,597	63,800	2,445	97,800	930	37,200	550	22,000	450	18,000
19	1,415	56,600	2,285	91,400	1,135	45,400	550	22,000	450	18,000
20	1,175	47,080	1,960	78,400	1,135	45,400	550	22,000	450	18,000
21	1,028	41,240	1,960	78,400	995	39,800	550	22,000	450	18,000
22	1,060	42,400	2,040	81,600	995	39,800	550	22,000	400	15,200
23	1,215	48,800	2,285	91,400	995	39,800	550	22,000	450	18,000
24	1,472	58,880	2,365	94,600	995	39,800	500	20,000	450	18,000
25	1,472	58,880	2,285	91,400	995	39,800	500	20,000	450	18,000
26	1,960	78,400	2,445	97,800	995	39,800	500	20,000	450	18,000
27	2,525	102,080	2,120	84,800	995	39,800	500	20,000	450	18,000
28	3,997	159,880	1,960	78,400	995	39,800	500	20,000	450	....
29	4,663	186,480	1,530	61,200	870	34,800	500	20,000	450	....
30	5,338	216,480	1,530	61,200	870	34,800	500	20,000	450	....
31	5,565	229,400	....	....	870	34,800	500	20,000	....	....

Figure 4 shows the amount of water diverted from West Gallatin River by all of the ditches and canals from June 10 to August 20, 1902, and the discharge of the river during that time. In comparing the amount diverted with the discharge in the river at Williams bridge, it is found that there was enough for all purposes. It should be kept in mind, however, that there was more than the average flow in this river in 1902. The discharge of the river from July 5 to August 20, 1900, was insufficient to furnish for all the ditches and canals the volumes diverted in the summer of 1902, and the same condition prevailed in 1901 from July 8 to August 20.

DUTY OF WATER UNDER WEST GALLATIN RIVER.

The irrigation season in the Gallatin Valley extends from about the middle or last of May until about August 15. There are, of course, localities where irrigation of some crops is begun before the middle of May, and where the season lasts beyond the middle of August. In such cases, however, the crop raised is usually not one of the regular crops of the valley, for these almost without exception receive the irrigation they require in the period mentioned. In many cases, although water is turned into the canals anywhere from the 1st to the 15th of May, extensive irrigation does not begin until in the forepart of June, depending almost entirely of course on the nature of the season, whether early or late.

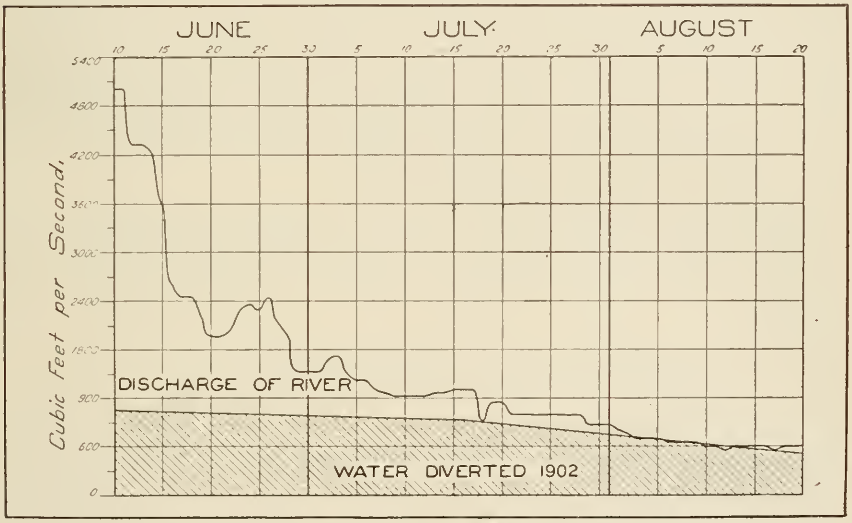

Fig. 4.—Discharge of West Gallatin River, 1902, and diversions therefrom.

The first crops to receive water in the spring are pastures and meadows, clover and alfalfa, after which the grain is watered. As grain is the main crop of the valley, irrigation occupies a large part of the season. After the grain is sufficiently watered and the first hay crop is cut, the water is again applied to the clover and alfalfa land for the second hay crop.

In the majority of cases alfalfa and clover receive but one watering for each crop, grain receiving from one to three waterings, according to the locality. The number of waterings depends of course largely on the rainfall both as to its amount and as to the time it is received. During the season of 1902 the rainfall came in sufficient amount and at such time as to make but one irrigation necessary for each crop of clover. Grain was well along also before irrigation became necessary.

During the spring of 1902 a series of investigations of the duty of water on West Gallatin River was instituted under some of the representative canals, and also a study of seepage losses from these canals as affecting the duty of water. Other studies were also carried on which had a direct bearing on these two phases of the investigations. The studies were confined to three canal systems which were chosen with special regard to their location, and for the reason that the conditions encountered under each system varied widely from those of the other systems, the three, however, representing nearly all the varying conditions of soil, methods of irrigation, and canal management to be found in the valley of the West Gallatin River.

The largest canal chosen for the investigation was the High Line canal, belonging to the West Gallatin Irrigation Company. This system was taken as representative of the larger incorporated canals, which head high up on the river and carry water for several miles before it is distributed to laterals. As a representative of the medium-sized cooperative canal, which conveys its water but a short distance before being used, thus eliminating any large seepage losses, the Kughen ditch was chosen. The third ditch was the Weaver and Stone ditch, representative of the small, private or individual ditch, heading on the lower section of the river.

Before the irrigation season opened recording instruments were installed on each of the canals, and throughout the season a continuous record of the amount of water flowing through each canal was obtained.

DUTY OF WATER UNDER HIGH LINE CANAL.

The register was installed in this canal on the Todd flume, about 2.5 miles below the head. At this point the canal crosses a narrow ravine in a flume about 30 feet long by 13.5 feet wide. In the following table is given the monthly flow from May 24 to August 31, inclusive, in cubic feet per second, Montana miner's inches, and acre-feet:

Discharge of West Gallatin High Line canal, 1902.

Month.	Average flow.		Discharge.
	Cu. ft. per sec.	*Miner's inches*	*Acre-feet.*
May (21-31)	35.8	1,432	569
June	60.8	2,432	3,619
July	90.4	3,616	5,556
August	44.4	1,776	2,728
Season	62.9	2,516	12,472

According to the annual report of Mr. E. C. Kinney, superintendent of the West Gallatin Company, there were 2,343 acres of land actually irrigated under the High Line canal. The duty given in the following summary is based on this estimate.

Quantity of water applied to lands under High Line canal, 1902.

Duration of irrigation season		May 24–August 31
Area irrigated	acres	2,343
Water received by land	acre-feet	12,472
Depth of water used in irrigation	feet	5.32
Depth of rainfall during season[a]	do	.39
Total depth of water received by land	do	5.71

The average flow of the canal at Todds flume was 62.9 cubic feet per second, or 2,516 miner's inches, giving a duty of water of 37 acres per cubic feet per second, or approximately 1 acre per inch.

The above values are based on the amount diverted from the river. In order to determine the amount of water applied to the land, seepage losses must be taken into consideration. During the season of 1902 seepage measurements were made on the High Line canal, with a view to determining the loss in different sections of the canal. In the following summary is given the result of the seepage test made in June, 1902.

Seepage in first 10 miles of High Line canal, measured June 24, 1902.

[In cubic feet per second.]

Discharge 0.5 mile below head gate	98.67
Discharge 1 mile tunnel	87.47
Loss in 10 miles	11.20
Loss per mile	1.12
Percentage of loss	11.35

In this first 10 miles there are no diversions. The canal traverses a steep sidehill almost the entire distance, gaining the top of the bench near the point where the lower measurement was made. On July 18, 1900, the seepage loss, measured in this same section when the discharge was 114.5 cubic feet per second at the head, was found to be 12.9 per cent of the amount entering the head. The loss in the next 16 miles was determined June 25. The results appear in the following table:

Seepage loss from High Line canal between mileposts 11 and 27 June 25, 1902.

[In cubic feet per second.]

Discharge near 11-mile post		89.69
Discharge near 27-mile post	19.87	
Diversions in section	54.71	
Total outflow from section		74.58
Loss in 16.5 miles		15.11
Loss per mile		.92
Percentage of loss per cent		16.85

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[a] Rainfall, assumed to be same as at Government Weather Bureau station, Bozeman.

The loss in this same section of canal as determined on July 19, 1900, was found to be 15.13 cubic feet per second when the discharge at the head of the section was 99.56 cubic feet per second.

Based on the measurements made in 1902, the seepage loss in the 26.5 miles of canal measured would be as follows:

Seepage loss in 26.5 miles of High Line canal, June 24–25, 1902.

[In cubic feet per second.]

Discharge at point 0.5 mile below head		98.68
Discharge near 27-mile post	19.87	
Diversions in section	54.71	
Total outflow from section		74.58
Loss		24.10
Correction due to change in flow of canal		2.22
Total loss in 26.5 miles		26.32
Loss per mile		.99
Percentage of loss per cent		26.67

Taking this 26.67 per cent as representing loss in transmission in main canal line, and disregarding losses in distributary laterals, we have as the depth of water on the 2,343 acres irrigated during 1902 4.19 feet.

DUTY OF WATER UNDER KUGHEN DITCH.

The rating flume on the Kughen ditch is located about 0.5 mile below the head of the canal and about 300 yards above where the first lateral takes water from the ditch. As there was no suitable structure on the canal which would answer as a rating flume, a new flume was placed in the canal. The section of the canal both above and below the flume for a distance of 100 to 200 yards is in splendid condition as to alignment and cross section. The flume is 14 feet long by 10 feet wide and so placed that little or no eddying is caused either by the waters entering or leaving the flume. The average depth of water in the flume when the canal was carrying its normal amount was about 2.5 feet.

This flume was provided with recording register and was carefully rated during the season. The daily flow from June 4 to August 16, inclusive, a period of seventy-four days, is summarized in the following table:

Discharge of Kughen ditch, 1902.

Month.	Average flow.		Discharge.
	Cu. ft. per sec.	*Miner's in.*	*Acre-feet.*
June (4–30)	49.4	1,976	2,646
July	58.6	2,344	3,603
August (1–16)	33.7	1,348	1,079
Season	49.9	1,996	7,328

The area irrigated during the season was obtained by a survey made for that purpose. Care was taken to eliminate all waste land, so that results obtained should represent the exact area devoted to crops.

In the following table is given the area devoted to the various crops raised on each farm entitled to water from the ditch:

Area of crops irrigated under Kughen ditch, 1902.

Name.	Barley.	Wheat.	Oats.	Flax.	Clover.	Timothy.	Pasture.	Summer fallow.	Total acreage.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Green Young	81.50	12.39					5.97	72.53	172.39
Joe Johnson	70.22		72.79					169.20	312.21
G. G. Johnson	37.52		231.16			43.62		195.14	407.44
D. Cameron	107.90		23.42				16.53	140.74	288.59
J. B. Corrie				121.68				110.88	232.56
William Lawrence							2.75	87.60	90.35
Frank Heiskell	160.80				3.44			117.09	281.33
T. E. Kirk	182.29							203.61	385.93
Catherine E. Clark	75.76								75.76
Mrs. A. J. Rowland	95.28							145.32	240.60
Mathias Nieble	87.80		56.24					136.58	280.62
Mary E. Matthews			39.02						39.02
J. White Place						36.77			36.77
Total	899.07	12.39	422.63	121.68	3.41	80.39	25.25	1,378.72	2,943.57

Deducting the 1,378.72 acres of summer-fallowed land, which received no water during the season, gives the area devoted to irrigated crops as 1,564.85 acres. Of this area over half was devoted to barley and the greater part of the remainder to oats, less than one-tenth the area producing hay crops.

The following summary shows the duty of water as based upon the area given above:

Duty of water under Kughen ditch, 1902.

Duration of irrigation season, June 4 to August 16	days	74
Area irrigated	acres	1,564.85
Water received by land	acre-feet	7,328.00
Depth of water used in irrigation	feet	4.68
Depth of rainfall	do	.33
Total depth of water received by land	do	5.01

Based on a period of seventy-four days, the average flow in the canal at the rating flume was 49.9 cubic feet per second, showing a duty of 31.34 acres per cubic foot per second; 1 inch was used for every 0.78 acre. As the water is used near the head of the ditch no correction need be made for seepage losses.

DUTY OF WATER UNDER WEAVER AND STONE DITCH.

As mentioned previously the Weaver and Stone ditch is representative of the small cooperative ditches which are quite numerous on the West Gallatin. It heads on the east side of the river 6 miles below the head of the Kughen ditch. From the point of diversion the ditch flows almost due north for a distance of 4.5 miles, where it reaches the two farms on which its waters are used. The rating flume in this canal was placed about 100 yards below the head of the ditch. The flume was made 8 feet long by 4.7 feet wide and was provided with a recording register. The season's record covered a period of seventy-seven days, extending from June 1 to August 16. The discharge of the ditch is summarized in the following table:

Discharge of Weaver and Stone ditch, 1902.

Month.	Average flow.		Discharge.
	Cu. ft. per sec.	*Miner's in.*	*Acre-feet.*
June	9.31	374	556
July	5.58	223	343
August (1-16)	7.15	286	228
Season	7.38	295	1,127

Only portions of the Weaver and Stone farms require irrigation, the remainder being sufficiently moist by reason of seepage waters from irrigated lands above. In order to obtain the acreage subject to irrigation during the season of 1902 a stadia survey was made. The results of this survey appear in the following table:

Irrigated lands under Weaver and Stone ditch, 1902.

Name.	Barley.	Wheat.	Oats.	Clover.	Alfalfa.	Wild hay.	Total.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
A. D. Weaver		74.69	4.59	3.21	23.13		105.62
D. Stone	38.12				40.18	17.22	95.52
Total	38.12	74.69	4.59	3.21	63.31	17.22	201.14

The total discharge for the season would cover this area to a depth of 5.56 feet. The average flow at the rating flume during the seventy-seven days of record was 7.38 cubic feet per second, making the duty of water 27.25 acres for each cubic foot per second, or 0.68 acre per inch.

A measurement to determine seepage losses in the long supply canal was made during the latter part of the season. This measurement showed that when there was a discharge of 4.52 cubic feet per second, the long transmission in the small ditch, without either uniform grade or cross section, caused a loss of approximately 50 per cent. When this is taken into consideration, the depth of water received by the Weaver and Stone farms is 2.78 feet. This is a duty of 54.5 acres per cubic foot per second, or 1.36 acres per inch.

WATER RIGHTS IN THE WEST GALLATIN BASIN.

Permanent settlement of the Gallatin Basin began in July, 1864, at which time J. M. Bozeman, the pioneer of the Bozeman route to the North Platte River, founded Bozeman, the county seat of Gallatin County. Since that time settlement has increased steadily until at the present time the entire cultivable area of the valley section is under private ownership, and, with the exception of a few scattering tracts in the mountainous section, no land is now open for settlement, the only means of acquirement being by purchase.

During the period of development, covering a space of nearly forty years, water for the irrigation of the lands of the valley has been taken promiscuously from the many streams, both large and small, which enter the valley. Until within the last few years water has been diverted from the various streams without let or hindrance.

The lands first to be reclaimed were those which were the easiest of cultivation and upon which water could be conveyed with but little difficulty. Such lands, almost without exception, were located on the lower parts of the streams, and it is in these sections that the oldest rights are found. As settlement of the valley increased, lands higher up on the stream were brought under cultivation and ditches were taken from the streams at the most convenient points.

The first ditches built were small, being individual or small cooperative enterprises. After all the easily available land had been brought under irrigation by these small systems, incorporated canal companies were formed which planned, and in a few instances constructed, large canal systems which head well up on the larger streams and by following long circuitous routes have been able to supply the higher bench lands. As no system of stream control existed, these diversions increased unrestrictedly from year to year until a slight shortage was felt by the irrigators on the lower part of the streams. When this stage was reached the lower irrigators, determined not to be thus deprived of their water supply, moved the heads of their ditches upstream to points where the river's supply was not so greatly depleted. On the same theory the next higher irrigator, when a shortage began to be felt, moved his head gate upstream also. As a result we have at the present time a system, especially noticeable on the West Gallatin River, in which numerous small individual and partnership ditches serve farms which lie anywhere from 2 to 6 miles below the points of diversion. These long parallel ditch lines, in addition to having required an immense amount of uncalled-for labor in their construction, are very ineffective as water carriers and lose by seepage in transit from 25 to 60 per cent of the amounts diverted. The scheme, therefore, which was originally intended to increase the water supply for the lower irrigators, has really been of little benefit to them, and has certainly been a serious drawback to the irrigated section in general.

The present condition is but a development of the conditions described above, only complicated somewhat by one or two recent years of short water supply. The man on the lower end of the stream claims those above him are using more water than their just share, while the man above says he has no more than he needs, but the large incorporated canals divert water in excess of their rights or needs, and allow the surplus to run back into the river at the ends of their canals too low down on the stream for subsequent diversion. The officers of the larger canals say there is water enough for all if only economical use is practiced. Meanwhile new appropriations are being made each year higher and higher on the tributaries. On some of the streams the day is long passed when the abundance of the supply served to prevent litigation, notably on Middle Creek.

The necessity for litigation arises from the fact that rights are acquired without public supervision and therefore without public records. While their existence is unquestioned, under existing laws they must remain undefined either as to volume or time until defined by the courts as a result of litigation between claimants. Naturally such litigation will not arise until the supply of water is insufficient to supply all demands.

In 1885 a law was enacted requiring all parties wishing to acquire rights to water to post notices stating the number of inches claimed; the purpose for which it is claimed; the place of intended use; the means of diversion, with size of flume, ditch, pipe, or aqueduct by which he intended to divert it; the date of appropriation, and the name of the appropriator. Within twenty days a copy of this notice, with the name of the stream and accurate description of the point of diversion, must be filed with the county clerk and verified by the affidavit of the appropriator or some one in his behalf. Within forty days after posting work must be begun, and must be prosecuted with reasonable diligence to completion. "If the ditch or flume when constructed is inadequate to convey the amount of water claimed in the notice aforesaid, the excess claimed above the capacity of the ditch or flume shall be subject to appropriation by any other person." If this law is complied with the right to the use of water relates back to the date of posting the notice.

It will be seen that the notice provided for is posted and filed before the work is begun and that the beginning of the work within forty days and its diligent prosecution to completion are necessary to the acquirement of a right, and that this right is limited by the capacity of the works, not by the amount claimed. The record, therefore, is evidence of the intention of the claimants only, and not in any way an index of the rights acquired.

The same law provided that those who had acquired rights previous to its passage should within six months file with the county clerks declarations in writing containing the same facts required in the notices previously referred to, "*Provided*, That a failure to comply with the requirements of this section shall in no wise work a forfeiture of such heretofore acquired rights, or prevent any such claimant from establishing such rights in the courts." This section is inoperative, because without the last clause it would be void and with it the record will be incomplete. The only value these records have is as "prima facie evidence of the statements therein contained." With a view to determining the completeness and the accuracy of this record, especially that portion relating to the rights in the Gallatin Basin, a careful and complete investigation was made of the entire record on file in the recorder's office of Gallatin County. The complete record occupies parts of 15 large volumes and contains between 2,000 and 3,000 recorded notices of appropriation and claims to water. Some of these records date back to the time when Gallatin County extended as far to the east as Billings and Miles City, and embraced the territory which now comprises the counties of Park, Sweetgrass, Carbon, Yellowstone, Rosebud, and Custer. Among the early records were found claims to water from such streams as the Musselshell and the Yellowstone rivers. Some of these old claims dated back to the "sixties" and represented some of the oldest rights on these streams.

Until within the last few years it was the custom to record all claims and notices of appropriation in the miscellaneous record and index it only as such. Within recent years, however, separate books have been provided for the water record, and in these have been placed all the notices and claims relative to the appropriation of water. This record is quite complete and easy of access.

In the following table are given the abstracts of the Gallatin Basin record, classed according to the stream on which the claims were made. The claims have been grouped according to the main stream and its tributaries, and are divided into "definite" and "indefinite" claims. The former contains all claims in which the amount of water is expressed in miner's inches or cubic feet per second, while the latter contains all claims in which the amount was expressed in indefinite terms, such, for instance, as "all the stream," "all this ditch will carry," "all this ditch takes," "sufficient for my land," and many similar expressions. The claims given for the West Gallatin River, Middle Creek, Bozeman Creek, East Bear or Flannery Creek, Rocky Canyon Creek, Bridger Creek, and the East Gallatin River are claims to water from the main streams themselves. The claims on the tributaries of these main streams are indented under the main streams.

Summary of recorded claims to water, Gallatin Basin.

Name of stream.	Definite claims.		Indefinite claims.	
	Number.	Amount.	Number.	Amount.
		Miner's ins.		
West Gallatin and tributaries	118	315,456	24	Various.
Cottonwood Creek (south)	11	7,590	2	Not given.
Bear Creek (west)	10	6,195	5	Claim all.
Wilson Creek	4	600	....	
Middle Creek	29	14,300	4	Not given.
Bozeman Creek	29	17,570	1 1	Claim all. Not given.
East Bear or Flannery Creek	14	4,161	....	
Rocky Canyon Creek	23	10,926	1	Do.
Bridger Creek	9	1,590	5 1 1	Claim all. Not given. One-third of stream.
Lyman Creek	11	2,460	6	Claim all.
Spring or Churn Creek	....	....	2	All of stream.
Cottonwood Creek	2	800	....	
Bostwick Creek	3	200	1	Not given.
Springhill or Ross Creek	17	15,610	4	All of stream.
Reese Creek	5	1,600	1	Do.
Dry Creek (north)	12	2,145	2	All; not given.
Dry Creek (south)	1	150	1	All of stream.
Doe Corran Creek	....	....	1	Not given.
East Gallatin River	8	3,147.5	7	Do.
Springs and creeks (not definitely located)	50	12,399	21	Various.

The foregoing table represents the entire water-right record of the Gallatin Basin, which comprises some 450 notices of appropriation and claims to water. As mentioned previously, this record can not be taken as a guide to existing rights for the reason that probably not to exceed one-half of the claims were followed by diversions, and for the further reason that probably not over two-thirds of the actual appropriators in the basin, taking the record of the West Gallatin River as a criterion, have ever had their rights recorded, the other third choosing to trust to diversion and use to validate their rights rather than go to the expense of recording their rights when such procedure guaranteed neither security of title nor immunity from litigation.

To bring out the extent to which the streams of the Gallatin Basin have been overappropriated or rather overclaimed, the data taken from the records and the results of the season's stream measurements have been brought together in the table which follows. It must be remembered that the values given under the head "Amount claimed" are only the amounts recorded in definite terms and do not include the large proportion of unrecorded rights or the rights which are recorded but do not have the amount claimed expressed in definite terms. The stream measurements, as mentioned in another part of this report, were made at points on the respective streams where their maximum flow would be encountered. The values given for stream flow are the averages of the measurements made during the irrigating season, which include both high and low water measurements.

Comparison of the definite claims to water, with the average discharge of streams of Gallatin Basin, season 1902.

Name of stream.	Number.	Amount.	Average discharge.	
		Miner's ins.	*Miner's ins.*	*Cu. ft. per sec.*
West Gallatin and tributaries	118	315,456	56,125	1,403.12
Cottonwood Creek (south)	11	7,590	3,528	88.21
Bear Creek (west)	10	6,195	944	23.61
Wilson Creek	4	600	353	8.83
Middle Creek	29	11,300	4,680	117.01
Bozeman Creek	29	17,570	1,412	35.29
East Bear or Flannery Creek	14	4,161	482	12.04
Rocky Canyon Creek	23	10,926	1,425	35.62
Bridger Creek	7	1,590	3,806	95.16
Lyman Creek	11	2,460	443	11.07
Cottonwood Creek	2	800	282	7.05
Springhill or Ross Creek	17	15,610	1,738	43.46
Reese Creek	5	1,600	930	23.25
Dry Creek (north)	12	2,145	282	7.05

On West Bear Creek, in addition to the definite claims, amounting to over six times the average flow, there are five claims which assert a right to the entire stream. Here we have a little stream whose average flow is about 1,000 inches filed upon to the extent of thirteen times its normal discharge. On Lyman Creek, the source of the city water supply of Bozeman, there are six claimants, each of whom has a recorded claim to the entire stream. On Bozeman, Bridger, Ross, Reese, and other important creeks the condition which exists is almost identical.

In 1905 a law was enacted providing for a further addition to the water-right records of the State. A person having filed a notice as required by law may, when his works are completed, file for record a map and statement showing the completed work, made and sworn to by a competent engineer. This law does not do away with the necessity of a court proceeding for the defining of rights, but it provides a means whereby an appropriator may make a public record of the essential facts as to his right—the location and capacity of his ditch, and the location and area of his irrigated lands as determined by surveys. The law is not mandatory, and will not make the record complete, but if an appropriator files a claim stating what he intends to do, and after completing his works files a map and statement according to law the evidence necessary for a proper defining of his right will always be at hand.

At the same time that provision was made for recording rights, it was provided that in any action regarding water rights all parties claiming rights to water from the same source might be made parties to the action, and all rights be determined in the one action.

WATER RIGHTS ON MIDDLE CREEK.

During the summer of 1864, John J. Chambers and Robert Gillespie settled on unsurveyed lands near the banks of Middle Creek about 6 miles west of the town of Bozeman. In the fall of 1864 these settlers conveyed about 100 miner's inches of water to land through two ditches dug to tap the waters of Middle Creek. In the years 1864 to 1869, inclusive, additional tracts of land were preempted, or homesteaded, by new settlers, each of whom either constructed his own ditch from Middle Creek or acquired an interest in his neighbor's ditch. These first settlers, to the number of thirteen, diverted streams at various points along the lower 9 miles of this creek and were subsequently known in the litigation which ensued as the Lower Middle Creek appropriators.

Lands had been acquired prior to 1870 in the vicinity of the upper part of Middle Creek, but no diversions had been made from this section of the stream. This delay is readily accounted for. The best agricultural lands were situated 1 or more miles from the channel of the stream; the cost of building ditches, owing to the high banks and the long distances, would be considerable, and, lastly, the lower irrigators, having acquired prior rights to the waters of the same stream, might contest the water rights of the upper settlers. To overcome the physical difficulties in the way of obtaining water for their land, and to procure greater financial strength in the prospective litigation with the lower Middle Creek irrigators, the settlers on the upper part of the stream formed themselves into an association, called the Upper Middle Creek Company. This was the first cooperative effort on the part of Middle Creek water users.

For the purpose of avoiding a conflict, this association began to negotiate with the farmers on the lower part of the stream. This resulted in the fall of 1871 in a contract which provided for an exchange of water. The Upper Middle Creek Company conceded to the lower users their prior rights to the waters of the creek, to the extent of the capacities of their several ditches, and agreed to construct and maintain a canal to convey water from the West Gallatin River to the channel of Middle Creek above the head gates of the lower users in quantities to equal if not to exceed the aggregate capacity of the lower ditches. The upper irrigators reasoned that if their association was willing to bear all the expenses in conveying water from a source which had an abundant surplus to the channel of Middle Creek they would then be entitled to divert from Middle Creek at higher points a volume of water equal to that which was to be conveyed from the West Gallatin River.

Several stipulations were inserted in this contract to protect the lower Middle Creek appropriators, the chief of which were that the upper company should acquire no rights to the use of said water until the supply ditch was built and furnishing water, and that the rights granted by the contract should be suspended if the quantity of water furnished through the supply ditch should be less than the aggregate of the quantities of water then taken out of Middle Creek by the lower appropriators.

In consideration of these stipulations the lower appropriators, citing the words of the contract, "do hereby give and grant unto the said members of the said ditch company and to their heirs and assigns our rights respectively to the use of the water naturally flowing in Middle Creek to the extent and capacity of said supply ditch of said company and the waters actually supplied by it into Middle Creek."

This contract was signed by nearly all of the lower appropriators, but never was acknowledged or recorded in the records of Gallatin County.

In pursuance of the contract the company completed the main portion of its ditch from Middle Creek and also the supply ditch from the West Gallatin River. The latter was begun in March and completed June 9, 1872. It was 12 feet wide on the bottom, with varying depths and grade, and was intended to carry 3,000 miner's inches. The contractors were paid by cash assessments levied on members of the association.

Middle Creek ditch was also built by the members of the same association. Instead, however, of levying an assessment payable in cash, each stockholder was required to provide a certain number of men and ox teams, and to perform an amount of work proportionate to his interest in the new canal. At that time one share entitled the owner to the use of 100 miner's inches.

For ten years after the building of Middle Creek canal there were disputes over water rights, but no court proceedings were instituted until the spring of 1883. During this interval a third disturbing element had been introduced in the form of thirty or more new appropriators, who had settled on lands above the Middle Creek canal and diverted water from the upper part of Middle Creek. The rights of these latest claimants, with one or two exceptions, were of later date than those of the lower Middle Creek appropriators and the Middle Creek Ditch Company, but their position on the stream gave them decided advantages.

In April, 1883, John M. Robinson and the lower appropriators to the number of twenty-one entered suit against Charles E. Hoy and thirty-eight other appropriators who had diverted water from the upper part of Middle Creek. At this time the lower irrigators had just cause to seek redress. The Upper Middle Creek Company had failed to comply with the terms of the contract signed in 1871, in that they neglected to maintain and operate the supply ditch from the West Gallatin River. This neglect on their part was trivial when compared with the damage inflicted on the plaintiffs by the new settlers, who, through their numerous ditches near the mouth of Middle Creek canyon, had diverted the greater part of the flow of the stream, causing it to become dry at times above the mouth of the supply ditch.

A decision was rendered by Judge Wade in October, 1883, in which he decreed 2,415 miner's inches to the twenty-two plaintiffs and 445 miner's inches to the thirty-nine defendants. Little benefit resulted to any of the interested parties from this suit. It was a futile attempt to adjudicate priorities between a certain number of claimants and to exclude others who had valid rights to the stream, but were neither plaintiffs nor defendants.

The Upper Middle Creek Company was maintained until 1886, when it was changed to a corporation under the name of the Upper Middle Creek Supply Ditch Company. This company was succeeded in January, 1890, by the present Middle Creek Ditch Company.

On July 15, 1890, the contract of 1871 was annulled by the consent of all parties in interest, and a new arrangement was made whereby the supply ditch with its water right was deeded to the lower Middle Creek appropriators by the Middle Creek Ditch Company in exchange for water rights on Middle Creek.

In 1889–90 the Middle Creek Ditch Company renewed the contest against the upper irrigators which was begun by John M. Robinson and his associates in 1883. This suit was known as the Middle Creek Ditch Company *v.* John J. Henry et al. There were in all twenty-two defendants, who had settled on bench lands near the mouth of the canyon, and had diverted water from Middle Creek for irrigation purposes for the most part subsequent to 1870.

More than two years elapsed between the time of issuing a writ of injunction against the defendants and the beginning of the trial. On July 9, 1889, the defendants were restrained from interfering with the waters of Middle Creek and on November 27, 1891, the trial began. There were so many witnesses to examine that the case occupied the time of the court for a period of twenty-three days.

April 22, 1892, the court rendered a decision, holding that when the lower claimants entered into the contract of 1871 for a consideration they abandoned all right and interest in the natural flow of Middle Creek. This ruling was extremely adverse to the Middle Creek Ditch Company, inasmuch as it changed the date of appropriation of nearly one-half of the flow of its canal from the years 1864, 1865, 1866, and 1867 to a time subsequent to 1871. The plaintiff company then moved for a new trial, and the motion being denied the case was appealed to the supreme court of the State. By a decision rendered April 1, 1895, the supreme court reversed the ruling of the lower court in excluding certain evidence and remanded the case for a new trial.

So, after nearly six years of litigation the litigants began to realize that little had been done toward a final settlement of their claims to water. The long-continued contest had converted former friends into enemies, the uncertainty in regard to the use of water had diminished the products of their fields, and the unusually heavy cash assessments that were levied annually to maintain their actions in court had deprived them of needed comforts at home. The demand for peace finally prevailed and a compromise was effected.

On August 15, 1896, an agreement was entered into regarding the dates of appropriation and the corresponding quantities of water which should be allotted to each legal claimant. This agreement, with the consent of all parties interested, was afterwards embodied in a decree rendered by Judge Henry, of the ninth judicial district, on March 11, 1897. The following is a summary of Judge Henry's decision:

> It is ordered that the plaintiff, the Middle Creek Ditch Company, is entitled to use and to the use, control, disposal, benefit, distribution, and enjoyment of 2,900 inches, statutory measurement (72.5 second-feet), of the waters of Middle Creek, according to the respective dates of appropriation thereof, and in the quantities of the said appropriations as follows:

Date of appropriation.	Name of appropriator.	Statutory inches.[a]	Remarks.
1861	Robert Gillespie	100	The first 13 appropriators herein given were known as the "Lower Middle Creek appropriators."
1864	John J. Chambers	100	
1865	Chris. M. Waterman	100	
1865	Horace Salter	100	
1865	Calvin Jewett	100	
1865	John McCormick	100	
1866	Elbert E. Robinson	100	
1866	John M. Robinson	100	
1866	Eliza B. Sanford	100	
1866	George Austin	100	
1867	Aaron T. Ford	100	
1867	James McCormick	100	
1869	Moses W. Goodall	100	
		1,300	
1866	Henry Monforten	100	
1870	John Kittle	100	
1871		100	Through Ray and Eckley ditch.
1871		100	Cline, Ferguson, and Baxter ditch.
1872		125	Mitchell, Cleveland, and Baxter ditch.
1872		200	Ray and Eckley ditch.
1873		150	Through Main canal.
1873		100	Cline, Ferguson, and Baxter ditch.
1875		175	Main canal.
1877		100	Do.
1879		75	Ray and Eckley ditch.
1880		100	Mitchell, Cleveland, and Baxter ditch.
1881		175	Cleveland, Ferguson, and Baxter ditch.
		1,600	

[a] 100 Montana statutory inches are equivalent to 2.5 second-feet.

The later appropriations, known as the Upper Middle Creek appropriations, amounting to 1,600 statutory inches (40 cubic feet per second), together with the former 1,300 statutory inches (32.5 cubic feet per second), make up the 2,900 inches, or 72.5 cubic feet per second, decreed to the plaintiffs.

To John J. Henry and his associates to the number of twenty-two, who were the defendants in the case, were decreed the following quantities:

Date of appropriation.	Name of appropriator.	Statutory inches.
June, 1866	John J. Henry and Edwin Hodgman	50
July, 1866	Henry Monforten	100
July, 1868	John J. Henry and Henry Hodgman	100
June, 1869	Randolph W. Brooks	100
October, 1869	White Caldwell	100
Do	Joseph Plumb	100
June, 1870	William Welch	100
April, 1872	do	100
June, 1872	William Kent	75
July, 1873	Henry Monforten	100
July, 1876	S. M. Gowan	100
April, 1877	James White	100
July, 1877	John J. Henry	200
May, 1878	Edwin Hodgman	100
Do	Charles Loverich	120
Do	Joseph McElroy	120
Do	Charles E. Hoy	250
June, 1878	Joseph McReynolds	100
Do	John D. Huffine	100
April, 1881	Charles Holmes (administrator)	125
July, 1881	Randolph W. Brooks	100
May, 1882	Charles E. Hoy	100
July, 1882	Henry Monforten	100
		2,540

The water rights of John J. Henry and Henry Hodgman, which date back to 1866 and include 150 inches (3.75 cubic feet per second in the decision), formed the old Penwell right, and the court permitted Henry and Hodgman to change the place of diversion from Lower Middle Creek to one near the mouth of the canyon.

Comment on the foregoing statement of facts seems unnecessary. It tells the familiar story of heroic efforts to subdue the desert and maintain at the same time an action in court over a contested water right.

From 1891 to 1895, inclusive, a period of five years, the Middle Creek Ditch Company levied in cash assessments $5,259.50. The disbursements of this sum are grouped under the following heads:

For services of attorney	$3,160.00
For court fees	999.30
For canal maintenance and repairs	737.20
For miscellaneous expenses	363.00
Total	5,259.50

The expenses in court fees are low, because the Middle Creek Ditch Company won the suit and the other litigants paid the greater part of the costs. The writer has no opportunity to ascertain accurately the aggregate cost to all the litigants. It is safe to say that if all the losses in time and money incurred by the irrigators of this stream in defending their rights to water were reckoned, the sum would reach $13,000.

The aggregate quantity of water decreed is 136 cubic feet per second. Assuming the present commercial value of a cubic foot per second, or 40 Montana statutory inches, in Middle Creek to be $300, the total value of the water adjudicated would be $40,800; that is to say, it has cost nearly one-third what the water is worth to obtain a judgment, and this judgment is of little practical benefit to the irrigators, because there is not a single measuring device on any of the ditches by means of which an appropriation can be measured, and in consequence the distribution is only guesswork, just as it was before a decree was rendered.

WATER RIGHTS ON WEST GALLATIN RIVER.

In the years 1864 and 1865, simultaneously with the early settlement on Middle Creek, the waters of the West Gallatin River were first used in the irrigation of the bottom lands along the lower reaches of the river. The greater number of these earlier ditches were individual or small cooperative enterprises. Between 1865 and 1880 the irrigated area increased steadily and to such an extent that greater effort was required than could be put forth by the small cooperative organizations; and at this time and during the succeeding eight or ten years the larger cooperative and canal organizations and incorporated companies came into existence and began the rapid extension of canals to the higher lands. Since 1890 a few new ditches have been constructed, but development has been chiefly along the line of extension of the older ditches.

The development of irrigation on this stream has been punctuated with many minor quarrels over water rights, but these for the most part have been on a small scale. The only case which has reached the courts and which has involved any considerable number of interests was a suit instituted in the district court in the spring of 1892. The suit was brought by T. J. Lynde, owner of considerable land near Salesville and also of a sawmill, which derived its power from the river at that point, against a great number of the older appropriators on the river. The suit was brought by stipulation for the purpose of legally defining the rights of the litigants and making the procedure a matter of record. In his complaint the plaintiff set forth as his chief cause for action that his was an old right to water, having been acquired by appropriation in 1868, and that in course of a few years the witnesses by whom he could establish his right to water would in all human probability die and he would then be unable to prove or establish this just right. In closing his complaint he took advantage of that section of the irrigation law providing that he might make all the appropriators from the same source defendants.

Such testimony as was taken in the trial of the case was of a superficial nature and little or no effort was made to verify the amounts of water claimed or the dates of first use as submitted by the defendants in their respective answers. By stipulation and agreement the defendants consented to the decree which gave to each party to the action, plaintiff and defendants alike, the amount of water claimed.

Owing, however, to the motives which prompted those interested in bringing suit and to the loose way in which the rights of the various parties to the action were determined, the decree fell into disrepute, and so far as the West Gallatin irrigators at the present time are concerned the action might as well have not been instituted. A law passed in 1905, making decrees "based upon evidence introduced and not upon stipulations or admissions of the parties" prima facie evidence of the facts therein contained, implies that the decree is equally valueless as a record to be used in defining rights in the future.

Up to within the last three or four years the river's supply has been adequate; but owing to an increased use of water and to one or two years of short water supply since, such as those of 1900 and 1901, the question of water rights has become a live issue and one which is causing a good deal of discussion among all appropriators, regardless of the size of their holdings.

During the season of 1900 the water supply was considerably less than in former years, and toward the lower end of the river the shortage was keenly felt. This shortage at the lower end was not due entirely to the decreased flow of the river, but was due to the lack of stream control, for had its flow been equitably distributed every one would have had sufficient for his needs. The ditches and canals higher up on the river diverted their usual amounts of water with the result that those on the lower reaches were forced to do with a short supply. This condition led to the organization of the Farmers' Defense Association by the appropriators on the lower reaches of the river.

This organization, as at first outlined, was to include only those whose rights dated prior to that of the West Gallatin Irrigation Company. Its object was to institute civil action against this company and all those holding subsequent rights and thus bring about a court adjudication of the various interests. The movement, however, was not generally popular and for the first year failed of its object. The following year, 1901, the water supply was still shorter than that of the previous year and early in the spring the organization was revived. It soon became apparent that unless the shortage was relieved by some means serious results would follow. During July the association sent a committee to interview the larger canal interests with a view to inducing them to decrease the amount of water they were diverting, so that the supply in the lower section of the river might be somewhat increased. The efforts of the committee met with success, and with this assistance the lower irrigators were enabled to get through the season. The generous action of the large companies had the effect of bringing all the irrigators on the river into a closer understanding, with the result that the original purpose of the association was abandoned and a reorganization affected. The association as reorganized was made to include all those who wished an amicable settlement of water rights. The idea, however, of resorting to the courts was still retained and although the membership of the association comprised only a small proportion of the West Gallatin irrigators, it nevertheless intended, if possible, to bring the question to an issue. Several law firms were interviewed by committees for the purpose of ascertaining the probable cost of the intended litigation. The terms of one firm were unique and present something new in the line of water-right protection; they offered to take the case for $40 per 100 inches of water obtained for each defendant. Nothing resulted, however, from the actions of the association, for as the season was drawing to a close and the farmers began to hope for a better supply the coming season, their desire to carry the question into the courts was lost sight of.

With the opening of the season of 1902 an attempt was made to again revive the organization, but there was prospect of a good water supply, and the whole matter of bringing about any concerted action was given up.

The association was instrumental in bringing relief to the lower irrigators in 1900 and 1901, and their efforts along this line were well timed and in the right direction, but it can not be admitted that their desire to precipitate a lawsuit over water rights was well advised. The entire absence of any reliable and trustworthy data or records regarding the various rights either as to the amount used or as to the date of appropriation would make hasty litigation just at the present time most disastrous.

What the irrigators of this section do not now possess and what is absolutely essential to an equitable and final adjudication of the stream may be enumerated under the following heads:

(1) Reliable data relative to the early use of water from each ditch and the subsequent enlargement and extension of the same.

(2) Trustworthy measurements of the flow of the West Gallatin River at various points along its course.

(3) An accurate determination of the capacities of all ditches and canals on the river.

(4) Accurate and simple means of measuring the flow in each ditch and canal, preferably a good rating flume or weir.

(5) Data as to the amount of water from each ditch and canal which is put to a beneficial use during an average season.

(6) An accurate survey and description of all lands which have been irrigated from each ditch.

It was with a view to getting such data that the special investigation of water rights and their relation to the use of water from the West

Gallatin was begun. As mentioned in another part of this report, the investigation included a series of measurements of the various ditches and canals diverting water from the river. In addition to the data thus obtained, a careful study of all existing water rights was made. This water-right study included not only those rights of which a record has been made, but also those of which there is no record and which depend entirely for their validity upon actual appropriation and use. The material thus gathered has been brought together in the following tables, one of which deals with canals on the east side of the river, beginning with the highest, while the other takes up the canals on the west side in a similar manner.

In the two columns under the head of "Date of appropriation" are given the recorded and claimed dates of appropriation. One column contains all rights which have been recorded, while the other contains the dates of appropriation claimed by those whose rights have not been recorded. The figures in the column of "mean flow" are derived from tables given in another part of this report (see p. 25), and are inserted in these tables for the purpose of showing the wide discrepancy between the amounts claimed and the amounts actually diverted.

West Gallatin River canals.

WEST SIDE OF RIVER.

Name of canal or ditch.	Date of appropriation.		Amount claimed.	Mean flow, 1902.	Acreage served.
	Recorded.	Claimed.			
			Inches.	*Inches.*	
Williams, No. 1	Aug. 15–18, 1886		400	160	320
Williams, No. 2 (lower)		1882	250	606	
Cockrill		1881	750	118	
Todd		1867	200	60	
West Gallatin (high line)	Aug. 7–18, 1889 May 9, 1890		50,000 50,000	3,669	
Sterling	July 7, 1883		1,000	254	160
Le Beau	1865–66		1,557	465	1,557
Railey	May 15, 1890		440	88	360
Gabriel	1866[a]		400	94	80
West Gallatin (short line)				869	
Kughen or Cameron	Aug. 25, 1882		3,600	2,421	2,943
Cameron, Nieble, Corrie & Clark		1875–76		555	1,500
Corrie		1880	200	35	100
Davidson, Leach, Smith & Heiskell	Aug. 26, 1882		2,000	1,136	1,895
Lewis	1865		7,750	779	2,395
Holgate & Grove	Mar. 26, 1889		1,000	502	320
Manhattan or Moreland	Oct. 5, 1889		3,000	744	5,440
Patterson & Boss	1889		2,000	356	680
White or Cayuse	June 12, 1883		3,000	1,008	1,360
Buckley, Curtis & Holgate	May 15, 1892		1,000	342	480
Lamphear & Bryan	May, 1887		300	276	280
Heeb & Kennedy		1865	400	118	
Heeb, No. 1		1872–1888	500	381	
Heeb, No. 2		1868	100		
Cruse, No. 1				138	
Lower Manhattan	1890		2,500	897	2,560
Baker	July 19, 1901		1,000	213	240

[a] Included in high-line appropriation.

West Gallatin River canals—Continued.

EAST SIDE OF RIVER.

Name of canal or ditch.	Date of appropriation.		Amount claimed.	Mean flow, 1902.	Acreage served.
	Recorded.	Claimed.			
			Inches.	*Inches.*	
Kleinschmidt				3,841	
Bush				396	
Ralph		1883	250	88	
Farmers, or Excelsior	Sept. 29, 1890		5,000	6,716	
Ferris				712	
Middle Creek Supply		1872	3,000	1,864	
Accola		1870	(a)	200	
Beck, Border, Spring & Matthews	Aug. 9, 1891		2,100	792	2,000
Tudor & Nieble		1865-66	350	165	280
		1885	120		120
Spain	Oct. 30, 1886		1,200	1,027	4,840
Waterman	Feb. 20, 1890		3,000		
	1866		2,600	200	
Ketterer, Owenhouse & Stephens	July 4, 1882		600		
	Apr. 12, 1883		200		
	May 1, 1887		1,500	1,107	1,000
	June 1, 1898		300		
	Dec. 20, 1899		[b] 220		
Knadler & Foerschler	June 28, 1887		900	465	600
Stephens & Creasy	June 10, 1888		100	133	320
Weaver & McDonald	Mar. 12, 1887		1,200	495	1,620
Knadler, White & Knadler		1886	200	32	30
Hoffman, Stephens & Cook	Mar. 1, 1887		1,200	437	800
Weaver & Stone	Aug., 1881		1,000	132	480
Learmouth, Ferguson, Owenhouse & Patterson	June 1, 1892		900	348	1,360
	May 13, 1901		[b] 30		
Hoffman & Marks	May 15, 1889		600	278	430
Bell, Franks & Creasy	May 20, 1887		1,000	224	900
Old Creamery ditch		1865	(c)	262	720
Dawes Bros. & Porter	July 14, 1882		(d)	245	380
Gibson & Green	Oct. 17, 1865		(c)	20	320

[a] All ditch will carry. [b] Cubic feet per second. [c] Not given. [d] All ditch takes.

As shown above, for only about two-thirds of the bona fide diversions from the West Gallatin River are claims recorded. On this subject of recording claims various irrigators expressed themselves. Those holding early rights which were not recorded made the statement that they felt that under the present law little was to be gained by recording their rights, and so long as it made no difference as to getting their water why should they go to the expense of recording when guaranteed no protection or benefit? On the other hand, those whose rights had been placed on record were prompted to the action on the principle that what would do no harm might some day do some good.

The season of 1902, differing from those of the two years previous, was one of abundant water supply. Even the irrigators generally admitted that there was no cause for complaint, and said that all were drawing more water than they actually needed, yet despite this fact the figures in the table show that there were only four out of the whole fifty-one ditches whose average flow for the season in any way equaled or exceeded the amount claimed for them, while the greater majority drew only a fraction of the amount claimed. Right here will be encountered the great difficulty when it comes to the final adjudication of the rights to the stream's flow. Irrigators who have set up a claim to a certain amount of water for years, probably not realizing in most instances the wide variation between the amount they use and the amount they claim, will, when the test comes, be loath to accept a smaller right, although it may be conclusively proved that they need no more.

APPLICATION OF WATER TO CROPS.

PREPARING THE LAND.

In Montana large expenditures have been made in building canals, but the skill which has been exercised in conveying water has not been extended to its proper application to the soil. This is usually attributed to the fact that irrigation has not been long practiced in Montana, and the time of the agricultural classes has been occupied mainly with the diversion and conveyance of water, leaving them little time to put their fields in proper condition to receive water. This is true of many of the new districts. The settler who is striving to make a home in an arid country on a small amount of capital can not well afford to spend $10 per acre for a water right and an additional $10 per acre in leveling, grading, and ditching his land. There is no valid excuse, however, for the people of the older-irrigated section continuing the use of the crude systems of pioneer days.

The methods of preparing land for irrigation in Montana do not differ materially in even widely separated sections. There is less tall sagebrush than in Utah or Idaho, and there is a larger and more uniform growth of native grasses. In old irrigated sections, like Gallatin Valley, there is little unbroken land under the ditches. The usual preparation is therefore confined to the surface of fields which have been cultivated and sown to crops for many years. Gang plows, disk plows, sulky plows, and the ordinary walking plows are all more or less used. In the work care is taken to leave the surface as level as possible after the plow and to avoid the making of dead furrows. If the surface is rough a disk harrow is used to break up the lumps. It is leveled and smoothed with one of the many kinds of home-made levelers, or with one of the patent levelers now on the market, and afterwards the seed is drilled in some 3 inches deep.

A method of preparing new land, somewhat novel in Montana, has of late been introduced in Beaverhead County. Much of the irrigable land of this county is comparatively smooth and level and covered with low sagebrush and rabbit brush. A supply ditch is first dug across the upper end of the field to be plowed and smaller ditches are run down the steepest slopes from the supply ditch. By means of these supply and lateral ditches the new land is thoroughly irrigated, and when the top layer of soil has sufficiently dried out to pulverize freely it is plowed, disked, and leveled. The method is described by J. E. Morse, of Dillon, Mont., as follows:

We begin irrigating as early as May 10, and thus get the use of the high water in the spring when it is abundant. Water is again used for this purpose during the fall months when it is not needed for regular crops. The land is broken up with 3-gang plows drawn by 8 horses. An outfit of this kind will average about 7 acres per day. Soon after plowing the corners of the field and the dead furrows are thoroughly disked. A leveler 24 feet long, made of square timbers and drawn by 6 or 8 horses, is then drawn diagonally with the way the land was plowed. The field is again disked, in part at least, and the homemade leveler is dragged diagonally across the field for a second time, but in a different direction from the first time. This second leveling will generally put the ground in first-class condition for seeding. The field lies in a state of rest or summer fallow until the following spring, when it is seeded to oats. This work can usually be commenced in March or whenever the frost is out of the ground and the soil is thoroughly dry on top. We use a disk drill, and with 4 horses can seed from 16 to 20 acres a day. The amount of seed varies from 85 pounds, when sown during the first half of Aprit, to 100 pounds when sown in May.

In some other parts of the State where irrigation is practiced the original surface is uneven, containing what is known as buffalo wallows. It is both difficult and costly to prepare such land for irrigation, the cost being sometimes over $10 per acre. The process of leveling involves the shifting of considerable quantities of earth. The grading, however, can not be successfully done on fresh sod, and the usual practice of preparing land of this character is to raise first a crop of wheat without water and when the sod is well decomposed and pulverized the grading can be done more cheaply and effectively. The removal of the top layer of soil from the high places in a field and its deposition in low places are also serious drawbacks, since the yield is much reduced on what was originally the edges of the wallows. Summer fallow and the action of frost, rain, and sunshine seem to be the common remedies for these spots. A heavy coating of manure is also beneficial.

Perhaps the most common mistake to be found in supply ditches is the steep grades on which many of them are built. In pioneer days water was conducted along plow furrows running down the steepest slope. A channel of this kind, although small at first, was gradually increased by erosion until it finally became in the majority of cases a wide, deep chasm. These unsightly channels detract from the appearance and value of a farm, and cause the waste of much water through seepage. The most obvious remedy is to change the location; but this can not be easily done, for the reason that the rights of way for such water courses have become vested in one or more owners, and the location can not be changed to one of less grade without an abandonment of the old and the purchase of the new right of way. In such cases, and for volumes not exceeding 200 miner's inches, the writer has recommended the use of tile pipes laid at least 1 foot below the surface, in order to permit the surface to be cultivated. The value of the crops that can be raised on the land occupied by such ditches will in a short time pay for the tile pipe. Other possible remedies are a change of location or the paving of the channel.

Again, it not infrequently happens that the supply ditch first built fails to furnish water to the whole of the farm. This may be due to its small size or its location too low to cover the higher ground. The remedy, always costly, is to build a second feed ditch and either abandon the first or operate and maintain both.

Still another mistake which is common to this and other States is the location of ditches without any regard to drainage. Water is frequently forced from a lower to a higher point along the border of a field by the construction of levees which interfere with and tend to choke the natural water courses. The consequences are a water-logged soil, the rise of alkali, and unprofitable yields.

FARM LATERALS.

These small ditches receive water from the supply ditch and distribute it over the surface. On grain fields the field laterals are run after the crop is seeded and usually when it is a few inches above the ground. In the majority of cases these furrows are run by eye from the bordering ditch at varying intervals. Regarding the direction of the furrows there are two well-defined methods practiced in the State. In one the laterals are located either on straight lines and extend more or less diagonally across the field. In the other the head ditch is located across the upper end of the field and the laterals are run at right angles from it down the steepest slope. When the surface of the ground is smooth and level and the laterals carefully run on a grade of 0.5 to 0.75 inch to the rod the first is preferable. Sometimes large quantities of fine sand or other material are carried down the supply ditch and choke up the small field ditches on slight grades. In cases of this kind the lateral on a steep grade preserves a clear channel and the sand is flushed out on the surface of the field. The distance between field laterals varies from about 70 feet in grain to 100 feet in hay fields. A 14 or 16 inch lister plow attached to a sulky frame and drawn by three horses is the implement most commonly used to make laterals. The furrows are cleaned out by a large shovel plow called a "dammer," which deposits a pile of earth in the laterals at intervals of 40 to 100 feet, depending on the grade.

Objections are made to the presence of so many laterals, in a grain field in particular. At first thought it would seem that the occupying of space by laterals lessens the yield to the extent of the surface not under crop. In accordance with this mistaken idea some men space the laterals far apart in order to effect a saving. As a matter of fact nothing is gained by a wide space of 150 feet between the laterals, for the head of water ordinarily used can not be spread evenly over so wide a belt. The result is uneven distribution and consequent loss of crops. Careful observation shows likewise that the yield is seldom much lessened by the presence of laterals for the following reasons: They increase the circulation of air and the amount of sunshine in a field bearing a medium or heavy crop, and they increase the yield along the lower edge of the lateral by subirrigation from the bed of the channel and by furnishing a top dressing of soil to nearby plants.

The cost of leveling fields that have been cultivated for a number of years and making the laterals varies from 10 to 75 cents an acre, depending on the character of the soil and the degree of thoroughness with which the work is done. A brief description of the methods adopted and the average cost of such work from a few of the most successful irrigators of Montana are herewith given:

Cost of preparing land for irrigation.

Description of methods used.	Cost per acre.	Name and address.
Land leveled, ditches made, and manure dams put in (first year, 50 cents).	$0.20	F. L. Benepe, Bozeman.
Land thoroughly leveled, laterals made with lister, and dams made.	.75	P. Bergland, Manhattan.
Land gone over with 4-horse leveler, and laterals made with disk plow.	.20	J. A. Lovely, Livingston,
Land leveled, laterals made with ditch plow, and earth and manure dams put in.	.75	G. M. Fuller, Bozeman.
Land leveled, laterals made, and dams put in	.50	H. Monforten, Bozeman.
Head ditches plowed after sowing, and dams made with dammer.	.25	E. C. Kinney, Bozeman.
Laterals made with 16-inch lister, and dams made with dammer.	.55	William Frank, Belgrade.
After cropping field leveled and laid off in lands about 15 yards wide by running lateral ditches that far apart, laterals made by throwing a furrow each way and running a wedge-shaped opener through them.	.08	J. E. Kanouse, Townsend.
Main ditch plowed and dirt pushed out with scraper, laterals made with lister, and manure dams put in.	.10	John Holliday, Livingston.
Furrows plowed 60 feet apart and furrows cleaned and dams made at same time with dammer.	.05	W. H. Sales, Salesville.
Laterals made 6 or 7 inches deep with 16-inch lister, and dams made with dammer.	.75	W. R. Bell, Central Park.
Land leveled, and laterals made by throwing a furrow each way and running a crowder through the ditch.	.25	P. Kircher, Clyde Park.

CHECKS IN LATERALS.

Reference has been made to dams of earth made by a dammer. These are confined principally to the grain farms. The most common kind of check for both grain and hay lands is a base of half-rotted straw or coarse stable manure covered over with a thin layer of earth. The manure is distributed in small heaps along the lateral, the space between the heaps varying from 30 to 80 feet, according to the grade. Before irrigation begins it is arranged so as to form a more compact check, and thin coverings of soil are usually placed over the upstream slopes. During the process of irrigating these checks are thrown out on the edge of the bank, leaving the channel free for the passage of water as far as the next check below.

In regions like the Yellowstone Valley, where alfalfa is the principal crop, some form of canvas dam is generally used. Some prefer to use manure for the checks in the smaller laterals and canvas dams for the larger laterals.

In still other districts of the State wooden or steel portable checks are used for the small ditches in the grain fields and canvas dams for the supply ditches.

AN IRRIGATION STREAM.

It is the prevalent opinion among Montana irrigators that one experienced man will handle 100 miner's inches in irrigating grain and a considerably larger stream in irrigating clover, alfalfa, or native meadow land. This head of water, if applied on 6⅔ acres, would cover it to a depth of 9 inches in twenty-four hours; or, it would cover 2.75 acres to the same depth in ten hours. It is only in rare cases that irrigators remain in the field at night. The stream is controlled by day, but before quitting time in the evening it is turned on some meadow or hay field to run without attention until morning. The results of such practice are to be seen in a low duty of water, diminished yields, and in time the water logging of soil and the creation of marshes. As land increases in value and as irrigation methods improve, the enormous waste of water caused by permitting an irrigation stream to flow over a field for twelve hours without guidance will be stopped. The division of the present large farms into smaller holdings and the production of a larger variety of crops will tend to introduce important changes in the use of water.

COST OF APPLYING WATER.

The cost of applying water depends on a number of conditions. In the short season of Montana some grain crops are irrigated only once. Other crops, such as alfalfa, clover, and native hay, may be irrigated three and four times. The size of the stream used also makes a difference in the cost, since the acreage watered in a day is usually in direct ratio to the head used. In addition there are to be found all kinds of surfaces. Some have been well prepared, and little difficulty is experienced in spreading water evenly. Others are uneven and poorly graded, with faulty supply ditches.

At the same time some idea of what it costs each season to irrigate a crop is highly desirable, not only for the western farmer, but especially for those who intend to take up farms in irrigated portions of the West. As far as Montana is concerned, it was thought that the most reliable information on this subject might be obtained from the irrigators themselves. Inquiries were addressed to a few of the most prominent of each community, and it was hoped their replies would apply in a general way to the entire community. The figures given in the following statement represent the average of 67 replies received from irrigators in different parts of the State.

Cost of applying water.

Irrigation head used by one irrigator	miner's inches	163
Number of acres irrigated by one man in one day	acres	5
Cost of one irrigation	per acre	$0.44
Cost of season's irrigation	do	$1.07

An idea of the methods employed may perhaps best be conveyed by a brief description of the irrigation of two staple crops in different parts of the State, viz, a grain crop grown in the Gallatin Valley and an alfalfa crop grown in the Yellowstone Valley.

IRRIGATING BARLEY IN GALLATIN VALLEY.

The land for a crop of barley in the Gallatin Valley is usually plowed in the fall just after harvest and is permitted to lie without further cultivation until the following spring. About the first of May the surface is usually dry and it can then be leveled, harrowed, and seeded. In that section the average rainfall for the two months of April and May is nearly 4.5 inches, enough for the needs of the plant until it is 5 to 7 inches above the ground. The barley crop reaches this stage the latter part of June and is then ready for the first irrigation. Assuming that the head ditch is already constructed and properly cleaned out, the first thing to be done is to mark out the laterals and furrow them out with a ditch plow. The marking out is often omitted, but when done the grade allowed in fields that have been carefully leveled is about 0.5 inch to the rod or, when a 100-foot chain is used, 0.2 foot to 100 feet. The laterals are spaced 60 to 80 feet apart, although the narrower space is to be preferred. Each one connects with the head ditch and is terminated about 50 feet from the lower border of the field. A dammer drawn by one horse follows the ditch plow and forms the earth checks, which are spaced about 60 feet apart. Canvas dams provide the most convenient check for the head ditch. By their use a stream of 75 to 125 miner's inches is divided between two neighboring laterals and the small areas lying between the supply ditch and the first checks are irrigated. The checks of earth are then broken with a long-handled shovel and the water flows in each lateral until it encounters the next check, where it is held until the next space is irrigated. In this way each of the strips lying immediately below each lateral is watered. A thorough irrigation consists in saturating the soil to a depth of 1 foot. In some seasons one irrigation will suffice. In dry years two waterings usually produce the largest yields. Sometimes the second irrigation is light, only part of the full supply required to saturate the soil being used. A volume of water equal to a depth of 6 inches spread evenly over the surface is usually sufficient, when there is no waste, for one thorough irrigation. When the land is uneven or not properly leveled or when it is broken up by ravines, there is usually considerable waste and it may require 9 to 12 inches in depth over the surface for one irrigation. Seldom more than half the quantity of water is used for a second irrigation. In the Gallatin Valley the first irrigation should be applied early in order to have the soil ready for the second application before the heads become too large and heavy. A heavy irrigation applied three weeks before the grain is cut may prove more injurious than beneficial, as the weak stems in the soft soil are not capable of supporting the heads in an upright position. Several days after the last irrigation the laterals are filled in and leveled in order not to obstruct the reaper. This may be done by the use of a small walking plow and two furrows or by means of a special implement containing two disks, which throw the earth to the center and fill the ditch.

Cost of irrigating a 40-acre barley field.

Leveling, ditching, and checking, at 75 cents per acre	$30.00
Value of water used, at $1 per acre	40.00
Applying sufficient water to mature crops, at 85 cents	34.00
Leveling laterals, at 7 cents per acre	2.80
Total	106.80
Gross returns from barley, 58 bushels, at 50 cents	1,160.00
Net returns	1,053.20

IRRIGATING ALFALFA IN YELLOWSTONE VALLEY.

Alfalfa being a perennial plant, the annual cost of plowing, cultivating, and seeding is saved. There is, however, more urgent need for thorough preparation at the time the crop is put in, since an uneven surface or badly located ditches may materially diminish the yields of every crop for a long period of years. The loss, from any one of these causes, of 100 pounds of alfalfa to the acre at each of three cuttings would amount to $9 per acre in twelve years, but such causes frequently reduce the yield to the extent of half a ton per acre, when the loss in the time named would amount to $108 per acre or about double the present value of alfalfa land.

In preparing a field for alfalfa it is better to plow it in the fall. It is then evenly graded and cultivated in the following spring as early as the ground is sufficiently dry to work and the seed drilled in to a depth of about 3 inches. The quantity of seed sown in the Yellowstone Valley averages about 22 pounds per acre. Many prefer to plow the laterals before seeding and to run the seeder as close as possible to the edge of the ditch. This prevents, for a time at least, the growth of alfalfa in the ditches.

Young plants are tender at first and require moist soil for a seed bed until the roots strike into subsoil that is continually moist. They are also liable to be choked by weeds. This can best be prevented by running a mower over the field with the knife set high. By this process the weeds are cut and make mulch, which prevents the soil from baking. The tops of the spindling alfalfa stems are likewise cut, which causes it to stool out and thicken.

In alfalfa fields the laterals should be located with an engineer's level or by some good substitute. The grade may vary from 0.2 to 0.3 foot per 100 feet, and the laterals may be spaced 75 to 125 feet apart. For a permanent crop of this character it also pays to construct wooden checks and division boxes in the supply ditches. When it is found necessary to divide an irrigation stream into two or three smaller heads a division box is convenient. The cost of a box of this kind is

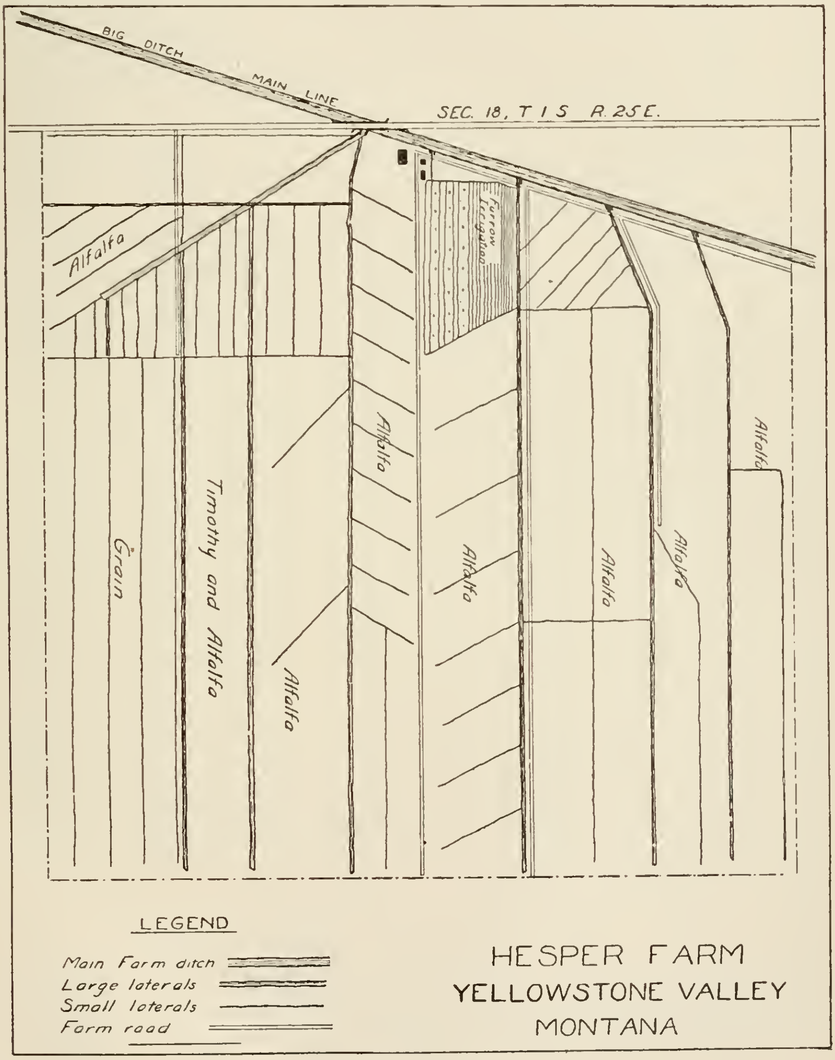
BIG DITCH MAIN LINE
SEC. 18, T 1 S R. 25 E.
Alfalfa
Furrow Irrigation
Grain
Timothy and Alfalfa
Alfalfa
Alfalfa
Alfalfa
Alfalfa
Alfalfa
Alfalfa
LEGEND
Main Farm ditch
Large laterals
Small laterals
Farm road
HESPER FARM
YELLOWSTONE VALLEY
MONTANA

FIG. 5.—Alfalfa field, showing location of laterals.

often refunded the first season in the lessening of the labor bill. By the use of a box of this kind a stream may be divided into three parts, in proportions to suit the convenience of the user, or it may be diverted from one course or lateral into another running in a different direction.

Old alfalfa fields in Yellowstone County are irrigated one to four times during the period of growth. Three crops are obtained from the same field in one season, and as a rule each crop is irrigated. One man handles 80 to 125 miner's inches. The laterals are somewhat larger than those found in grain fields and the water is checked by canvas dams. Occasionally one sees a farmer who uses manure for checks, but the large majority use canvas. Water is distributed as in grain fields (fig. 5). The proper time for each irrigation and the proper amount of water to apply are questions that have not been definitely settled. Too little water diminishes the yield and too much injures the soil by bringing up the alkali. Between these two extremes there is usually some middle course which will produce the best results. For the past three years the average amount of water used by the farmers under the Big ditch, in Yellowstone County, has been 41 inches in depth over an area aggregating 18,000 acres. This includes all losses of all kinds, but making a liberal allowance for waste there would remain about 30 inches, or 10 inches in depth for each of three irrigations. As to the proper time to irrigate, the first application should be made before the crop begins to suffer. It is too late when the plants show the effect of drought. As regards the proper time to irrigate the second crop opinions differ, but it is a common practice in Utah to irrigate just after taking off the first crop. The majority claim that on the large farms of the Yellowstone Valley it is not practicable to remove a crop in the forenoon and spread water over the surface the same day. These contend that so much time elapses between the cutting of the alfalfa and the irrigation of the stubble that the latter is badly injured and takes a long time to recover after being watered. Those who hold this view prefer to apply the water before the alfalfa crop is cut, allowing sufficient time for the drying out of the soil before cutting.

Cost of irrigating a 40-acre alfalfa field.

Interest on cost of preparing land, at 50 cents per acre	$20
Repairing and cleaning out laterals, at 25 cents per acre	10
Cost of water used, at $1.50 per acre	60
Cost of irrigating three times, at $1.25 per acre	50
Total	140
Gross receipts from three cuttings, 6 tons at $5 per ton	1,200
Gross receipts, less cost of irrigation, on 40 acres	1,060

DUTY OF WATER IN MONTANA.

Montana is a large State, but the bulk of its agricultural products will always be raised on comparatively small areas, because of the limited water supply. This being true, the duty that can be secured for its water supply will measure to a large degree the future possibilities in agriculture. For this reason the study of the duty of water and the conditions which influence it assume great importance.

If it is desired to reclaim an arid tract of land the engineer must decide not only upon the total quantity required for the season but also the maximum amount to be delivered at any one time. Having decided as to the largest volume of water required for any given period, he designs the canal structures accordingly. If this estimate is too large, a part of the money of the investor will serve no useful purpose. On the other hand, if the estimate is too small, the enterprise will be a partial failure, for there will not be sufficient water to irrigate all the land. Similarly, when water is to be stored to irrigate land, the capacity of the storage reservoir and the cost of the structure are both dependent to a large extent on the service which the stored water will perform when applied to the soil. There is the same necessity for accurate information on this point when a pumping plant is to be installed. Otherwise money will be wasted in the purchase of a plant of too large capacity or else the plant first installed will be too small to raise the requisite amount of water and will have to be replaced by one of greater capacity.

Thus it is evident that from an engineering standpoint a knowledge of the amount of water required for land of a known character and for particular crops is necessary. Such knowledge is all the more important when one considers that about 80 per cent of the irrigable lands of Montana is yet to be reclaimed. Judging from the progress made during the past fifteen years, the extent of land reclaimed in the next fifteen years by private enterprise will amount to 1,750,000 acres. If this area is increased by a third of a million acres of Government land, which it is presumed will be reclaimed by the Federal Government under the operation of the irrigation act passed June 17, 1902, it will increase the amount to over 2,000,000 acres. There is perhaps no question of more vital importance to the future of Montana than a knowledge of the right amount of water to apply, not only to the land which may be irrigated in the next fifteen years, but to all the irrigable lands.

When one considers the broader features of this subject, which pertain to the equitable allotment and distribution of water, its importance is much increased. The basis of all equitable allotments must rest on the amount of water required to properly irrigate land. This question thus becomes one of the main factors in the determination of rights to the use of water. Even after rights have been established, the proper duty of water is still the cause of much dispute between those who regulate, control, and administer the public waters of a stream and the farmers who use the water.

SOME CONDITIONS WHICH AFFECT THE DUTY OF WATER.

The ordinary irrigation channel receives much more water from the stream than it delivers to the irrigated fields. Porous soil and a high summer temperature cause losses in conveyance in the main canals, seldom less than 10 per cent and rising occasionally to over 50 per cent of the total volume diverted. The flow, after it is turned out of the main canal into laterals, is subjected to a still further reduction in volume from the same causes, so that in stating the quantity of water used on a tract of land it is important to locate definitely the place of measurement. When the irrigation stream is measured as it crosses the highest boundary of a field there is practically no loss in conveyance. When, however, the water is measured at the point of diversion from the natural channel, all losses due to seepage, evaporation, and leakage are included, and this shows a much larger quantity used.

Rainfall, midsummer temperatures, and the length of the irrigation period all modify the quantity of water required. In Montana all three conditions are favorable from the standpoint of the economical use of the water supply. The average annual precipitation over the cultivated portions of the State is over 14 inches, and a large part of this occurs in April, May, and June, when farmers need moisture most to start their crops. In the Gallatin Valley in particular the rainfall during these three spring months is fully equal to one irrigation, and forms about 30 per cent of the average amount of water received by fields under careful irrigation. The evaporation is likewise low during the time when water is applied. The average weekly evaporation from a water surface at Bozeman, Mont., for the past four years has been 0.94 inch for the months of May, June, July, and August—much less than it is in the more southerly and warmer portions of the arid region. For the same reason the period during which water can be used is comparatively short. In some parts of the State irrigation water is applied in April and May, but, taken as a whole, the ordinary crops receive the greater part of the season's supply from May 15 to August 15. The average length of the irrigation period in Montana does not exceed one hundred days.

Water can seldom be economically used on a one-crop farm. This is particularly true of the cereals. If one's holding is all planted to wheat, for example, a large flow may be required for a short period, but when the needs of this one crop are supplied the owner may have no further use for the irrigation stream. In growing alfalfa, or any other leguminous crop, under irrigation it is possible to get a higher duty out of the water supply, for the reason that two or three crops may be grown on the same field in one season. A farmer who is entitled to the continuous use of 1 cubic foot per second for 80 acres may thus be able to supply water to three crops of alfalfa at the same cost as to one crop of wheat. In doing this he may use more than three times the amount of water, but, assuming that he pays season rates, the cost would not differ.

It is only, however, on the diversified farm that a continuous stream can be utilized to the fullest extent. When a dozen different crops are grown on an 80-acre farm the proper time to irrigate is seldom the same for any two, and so it is possible to keep a small stream flowing continuously on first one and then another of the subdivisions.

On account of the large size of the average farm and the plentiful supply of water, the necessity for time rotation in the delivery of water has not been keenly felt in Montana up to the present. It is only when a scarcity exists that neighbors arrange to use in turn the supply which belongs to, say, three proprietors. In this way each of three farms can secure an effective irrigation head for one out of every three days. As water becomes scarce and of higher value and as the farms become reduced in size this method of delivering water will gradually become more common.

The subsoils of western lands when first brought under irrigation contain little moisture. The most striking characteristics of these formations are their great depths and the close similarity which exists between the surface and subsurface layers. Apart from their darker color, due to decayed vegetable matter, there is little to distinguish top soils from bottom soils, and the roots of plants extend to great depth through the latter. On account of these prevailing physical features a large part of the water which is applied for the first few seasons is absorbed. Cases are common in which new land has absorbed in one season a quantity of water which would have covered the surface to a depth of 6 feet. To claim that this large volume correctly represents the duty for such land is a misrepresentation, because the open space in the subsoil is gradually filled with water and the ground-water level in time rises nearer the surface. It is a fact, however, that new land requires much more water per acre than old cultivated fields, and crops are likely to suffer if it is not supplied.

Other conditions being similar, less water will be used on a farm which has a good system of ditches and laterals and a well-cultivated even surface. The beginner is not always posted as to the best way to lay out and build farm ditches, and he may not possess sufficient means to properly prepare his fields for irrigation. These defects invariably prove quite costly in the end, when measured in waste of water and small yields. In an arid country thorough cultivation serves a double purpose in that it increases the yield and prevents the escape of water into the atmosphere. Grading or leveling the surface is even more important, since it is difficult to apply water to an uneven surface, the growth of the crop is not uniform, and the soil in the low places is likely to be damaged by an excess of water.

The time necessary to mature plants differs. Under favorable conditions a crop of alfalfa can be grown in less than fifty days, a crop of barley in something over one hundred days, while it may require one hundred and fifty days to ripen certain varieties of fruit. There is not only a difference in the period of growth, but also in the number of crops grown in one season.

The way in which water is applied is perhaps as important as the quantity used. Some soils bake after being flooded and furrow irrigation must be used for all crops. Other soils are so porous that furrow irrigation is not practicable. In irrigation by flooding, as generally practiced in Montana, care is usually taken to distribute the water during the day, but it is left unattended during the night. Fully 20 per cent of the available supply may be wasted while the irrigator sleeps or is off duty.

A part of the Gallatin Valley is underlaid by coarse gravel and cobbles and a large percentage of the water applied to the surface sinks into these porous materials and drains down the valley. Other portions are undulating, which renders the application of water somewhat difficult.

In the Bitter Root Valley much of the fruit soil is light and porous, and is located for the most part on steep slopes. For these reasons the amount of water used is considerably above the average. Along the Milk River Valley the slope is flat and the soil somewhat heavy. These conditions favor a high duty, and when this part of the State is further developed it is expected that a cubic foot per second will be sufficient for 100 acres.

It frequently happens that fields which have received large quantities of water produce low yields. This result may be due to one or more of a large number of causes. Chief in importance is the proper cultivation of the soil. It may be regarded as one of the fundamental truths in agriculture that irrigation can not take the place of cultivation. The western irrigator has been slow to recognize this fact, and is still inclined to depend too much on irrigation and too little on cultivation. As a rule, in Montana the largest and most profitable yields are obtained from the use of a moderate amount of water. The people of Gallatin Valley, who produce the largest yield of grain in the State, use the least amount of water in irrigation.

Throughout the most productive regions of the State sufficient water is diverted to cover the land watered to depths varying from 3 to 5 feet, but since a large percentage is lost in transit the volume which reaches the fields would not cover them to depths greater than 20 to

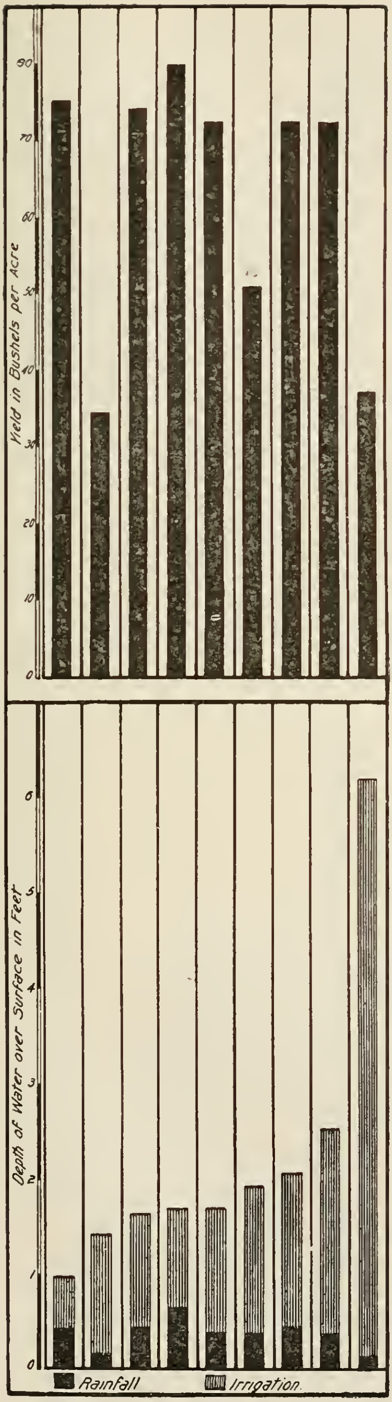

FIG. 6.—Depth of water received by oats, and yields.

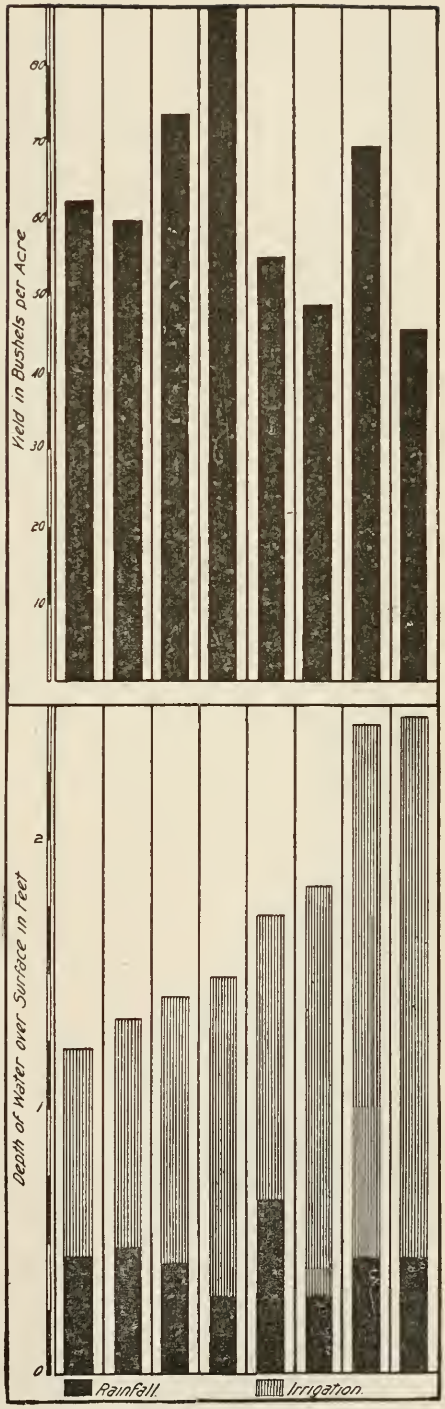

FIG. 7.—Depth of water received by barley, and yields.

40 inches in a season. There are other portions where water is so cheap and plentiful that the owners are careless in its use. They open the head gates and permit a large stream to flow for days at a time without much, if any, attention. Men who use large quantities of water, covering their fields to depths of from 4 to 10 feet every season, are usually the most careless in preparing the land or in cultivating the surface, and the result is without exception a small yield.

That yields do not depend wholly on the amount of water applied is clearly shown by figure 6. This diagram shows the amount of rainfall and irrigation water received by eight oat fields, with the corresponding yields. The lower half of the diagram shows the depth of water received and the upper half the yields on corresponding tracts. A field which received over 6 feet of water in two irrigations produced only 37 bushels per acre, while a field which received in one watering less than 7 inches produced 75.5 bushels. The largest yield was 80⅓ bushels per acre from a field which received 1.04 feet of irrigation water and 0.64 foot of rain water.

In figure 7 are shown like results on eight fields of barley. There are no large amounts of water used, all being less than 30 inches in depth. Still, the largest yield was not obtained from the use of the most water, which was 1.98 feet of irrigation water and 0.42 foot of rain, or 2.40 in all. A yield of 87.25 bushels was harvested from the field which received less than 18 inches in both rain and ditch water.

The results of six wheat crops shown in figure 8 indicate that the amounts of water used ranged from a small to a medium amount and that the yields varied to some extent with the water applied.

Figure 9 shows yields of clover and the quantities of water applied to nine clover fields. In this crop the largest yield was from the heaviest watering, but, on the other hand, the next largest use of water produced a small crop.

In comparing records of thirty-two irrigated fields, as given in the diagrams, the conditions under which the crops were grown should be considered. It is important to remember that the crops were grown in different seasons, in different parts of the State, and in many cases under a wide diversity of soil and climate. In view of this fact, the records as given should not be used to base conclusions as to the proper amount of water to use in the raising of these staple crops. They do show, however, that when other conditions are favorable it is possible to obtain a large crop with a small amount of water.

UNITS OF MEASUREMENT.

In the measurements of duty of water reported in the subsequent pages several units are employed to state the quantities of water used. The irrigators generally use the term miner's inch, being unfamiliar with the term cubic foot per second. As it is impracticable to

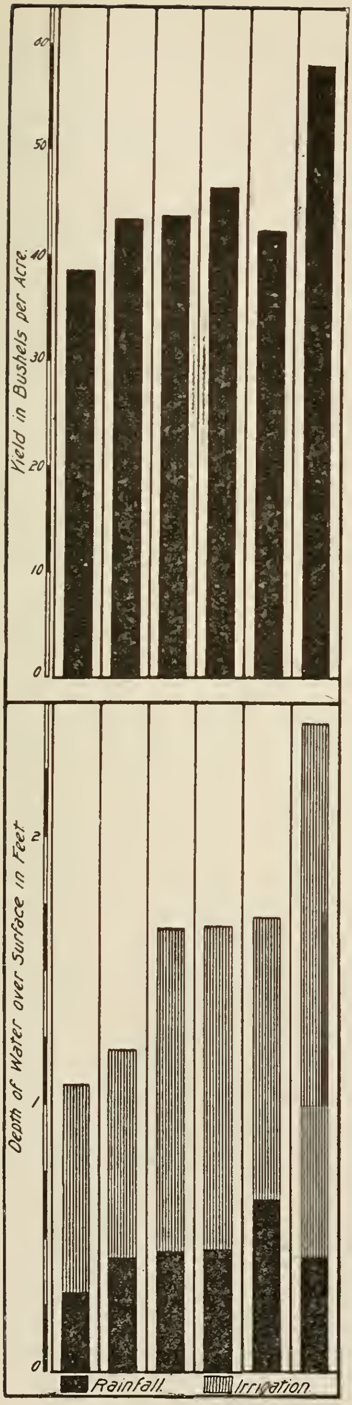

FIG. 8.—Depth of water received by wheat, and yields.

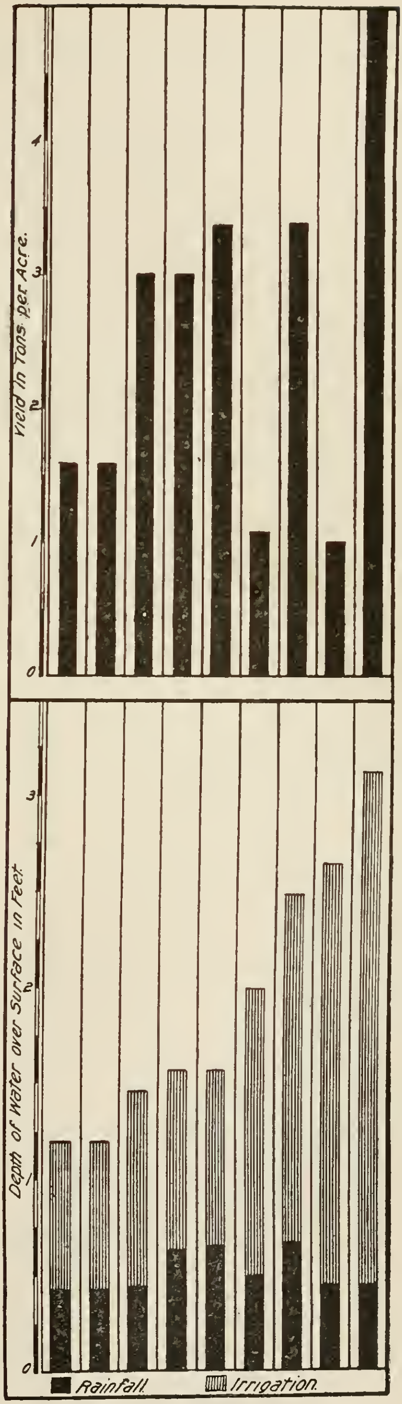

FIG. 9.—Depth of water received by clover, and yields.

measure either a large canal or a stream by means of a miner's-inch box, all measurements were made in cubic feet per second, according to modern methods, and afterwards reduced to miner's inches.

Prior to 1885 Montana had no legal standard for measuring water in motion. In that year the legislature enacted the following somewhat imperfect description of a measuring box:

> SEC. 1262. The measurement of water appropriated under this chapter shall be conducted in the following manner: A box or flume shall be constructed with a head gate placed so as to leave an opening of 6 inches between the bottom of the box or flume and the lower edge of the head gate, with a slide to enter at one side of and of sufficient width to close the opening left by the head gate by means of which the dimensions of the opening are to be adjusted. The box or flume shall be placed level and so arranged that the stream in passing through the aperture is not obstructed by back water or an eddy below the gate, but before entering the opening to be measured the stream shall be brought to an eddy and shall stand 3 inches on the head gate and above the opening. The number of square inches contained in the opening shall be the measure of inches of water.

For thirteen years the miner's-inch box just described was the only legal means of measuring irrigation water, and all court decrees which were rendered from 1885 to the spring of 1898 and which deal with specified volumes of water used in irrigation are expressed in Montana statutory inches. While a new standard unit has been adopted, the old unit can not be said to be wholly abolished. Parties whose rights to the use of water were established during this thirteen-year period have been granted the privilege of having the quantity of water to which each is entitled measured by the miner's-inch box.[a]

Since 1898 the standard unit in Montana for the measurement of water in motion is the cubic foot per second, a cubic foot of water moving at the rate of 1 linear foot in one second of time. In adopting a new standard the members of the Montana legislature foresaw the extended use of the old unit and so defined it in accurate terms. Forty miner's inches are the exact equivalent of 1 cubic foot per second and the volume of 1 miner's inch is equal to 0.025 cubic foot per second.

The miner's inch and the cubic foot per second can only be used to measure water in motion. Since it is often convenient to describe a certain quantity of water in a state of rest, the acre-foot has been quite generally adopted for this purpose. It means the amount of water that will cover 1 acre to a depth of 1 foot, or 43,560 cubic feet, or 325,851 United States gallons.

HOW MEASUREMENTS WERE MADE.

In ascertaining the amount of water applied to individual crops it was customary to measure the stream at the upper boundary of the field. This was done in most cases by placing a Cipolletti weir of the proper size in the supply ditch. The canals were measured at rating flumes placed near the point of diversion, the velocity being determined by a current meter. In the Gallatin Valley the fluctuations in the water levels of both the small ditches and the canals were measured and recorded by a recording instrument, but in the Bitter Root and Yellowstone valleys no instruments were available, and daily observations were made of the height of water at the several gauges by the ditch riders, who kept the records in a book provided for that purpose.

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[a] See description by author in Montana Sta. Bul. 34, p. 4.

In fenced fields the area contained within the fence lines was taken, but in smaller fields only the area cropped, together with the space occupied by the head ditches, was included. The area of land under most of the canals investigated in the Bitter Root Valley was found by actual survey. From 1889 to 1901, inclusive, on account of the lack of funds, no surveys were made of the Yellowstone or Gallatin Valley canals. The total area irrigated under each canal was computed from estimates obtained from the owners by a house-to-house canvass. In 1902 careful surveys were made of the irrigated lands under each canal, thereby checking the estimates of previous years.

THE QUANTITY OF WATER APPLIED TO INDIVIDUAL CROPS.

MEASUREMENTS MADE IN 1899.

In 1899 an effort to determine the duty of water in the Gallatin Valley was made by the irrigation and drainage investigations of the Office of Experiment Stations, United States Department of Agriculture, in cooperation with the Montana Experiment Station. In selecting the fields care was taken to have them represent as nearly as possible the average conditions of that vicinity. No attempt was ever made to control the amount of water used. The farmer was free to use as much water as he deemed necessary. The work for the first season consisted in determining the amount of water applied to eight fields and the duty of water under Middle Creek canal. Five of the field tests were made on the station farm and the remaining three on adjacent farms. Descriptions of these fields were published in a former bulletin.[a] The soil in general consists of a clay loam from 30 to 70 inches deep, with a porous stratum of gravel wash beneath. No water was used on any of the eight fields before June 17, 1899, and on that date the irrigation of a field of red clover was begun. It was June 23 when the first of the seven grain fields was irrigated, and no water was applied on these after July 26. The last watering of the clover field took place August 2. In the following table are given for each field the number of acres irrigated, the yield per acre, the rainfall during the period of growth, and the duty.

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 86.

Summary of results of duty of water experiments on field crops in Gallatin County, in 1899.

Crop.	Area irrigated.	Yield per acre.	Number of irrigations.	Rainfall during growth.	Depth applied.
	Acres.			*Foot.*	*Feet.*
Clover	27.44	3 tons	2	0.41	1.02
Peas	4.23	31.25 bushels	2	.41	1.10
Grain	11.27	57.89 bushels	2	.42	1.98
Barley	66.39	73 bushels	1	.41	.98
Oats	23.41	51 bushels	1	.38	1.53
Do	7.26	72.75 bushels	2	.36	1.34
Do	2.48	72.75 bushels	2	.36	2.16
Do	25.09		1	.44	1.28

MEASUREMENTS MADE IN 1900.

The measurements made in 1900 to determine the duty of water on individual fields were not confined to the Gallatin Valley, but were extended to the Bitter Root and Yellowstone valleys.[a] The crops tested in the Gallatin Valley were grain and red clover. Water was first used June 4 and its use was continued until August 14. The clover crops were irrigated from two to four times and the grain crops were each irrigated twice. The former received on an average 18 inches in depth, of which 4 inches was rain; the latter received 26.5 inches, of which nearly 5 inches was rain.

The quantity of water applied to three fields belonging to the Bitter Root stock farm of Ravalli County was determined. The first of these consisted of a 40-acre tract of 5-year-old orchard trees. A light vegetable loam formed the top soil, with a subsoil of gravel and small cobbles. Light irrigations were applied in April, June, July, and August, but the aggregate of the four with the rainfall was only 18 inches in depth over the surface. The quantity of water applied in two irrigations to a large field of oats on the same stock farm was 17 inches.

The third experiment was made on a high gravelly bench traversed by numerous ravines, and much of the water used was apparently wasted. The yield of oats averaged 34 bushels, and yet the volume applied in two irrigations would have covered the tract of 102.2 acres to a depth of 6 feet.

In Yellowstone County the amount of water used on a field of alfalfa comprising 53.4 acres was measured. Three crops were grown with only one heavy irrigation. The yield per acre for the season was 5.17 tons, and the depth of water applied was 16 inches. This practice of raising so many crops with one application of water is not representative of this alfalfa-raising district. Many raise four crops in one season, and water the land for each crop. In doing so each irrigation would be comparatively light, probably not over 9 inches, or 36 inches for the season. The results at all these places in 1900 are given below.

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 104, pp. 267–292.

Summary of results of the duty of water experiments on field crops made in 1900.

Crop.	Area irrigated.	Yield per acre.	Number of irrigations.	Rainfall.	Depth applied.
	Acres.			*Foot.*	*Feet.*
Clover[a]	66.39		2	0.44	1.98
Barley[a]	4.14	48.50 bushels	2	.28	1.50
Oats[a]	25.09		2	.39	.84
Wheat[a]	2.00	38.33 bushels	2	.30	.77
Clover[a]		3,170 pounds	2		
Oats[a]	2.00	75.58 bushels	2	.39	.57
Peas[a]		1,330 pounds	2		
Barley[a]	1.00	87.29 bushels	2	.28	1.17
Oats[a]	8.51	74.67 bushels	2	.40	1.27
Barley[a]	4.52	68.58 bushels	2	.42	1.96
Clover[a]	7.26	5 tons	4	.44	2.70
Do	35.90		3	.44	1.78
Alfalfa[b]	53.41	5.17 tons	1	.45	1.30
Orchard[c]	40.00		4	.13	1.48
Oats[c]	161.70	33 bushels	2	.13	1.28
Do	102.20	31 bushels	2	.13	6.00

[a] Gallatin County. [b] Yellowstone County. [c] Ravalli County.

MEASUREMENTS MADE IN 1901.

The investigations of 1901 were a continuation of those conducted in former years.[a] The crops of Gallatin County were six clover fields, seven grain fields, and one sugar-beet field. The clover crops were irrigated from one to three times and the average quantity of water applied during the season was 14.5 inches. To this should be added the rainfall, which averaged 7.2 inches, making a total of 21.7 inches. The amounts applied to seven grain crops were a trifle less than 12 inches of irrigation water and nearly 6 inches of rain water, or 18 inches in all. The sugar beets were irrigated three times and received 24.6 inches in both irrigation and rain water.

The same three fields in Ravalli County on which water was measured in 1900 were tested in 1901. The 40-acre tract of 6-year-old orchard trees was again watered four times and the average depth of water used in irrigation was 18.7 inches, while the rainfall was 5.9 inches, a total of 24.6 inches. The second field produced 150 tons of clover hay with the use of 18 inches of irrigation water and 6 inches of rainfall; and the third field, on which so much water had been applied the year previous, produced 103 tons of clover hay with the use of 5.5 inches of rainfall and 26.5 inches of ditch water.

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 119, pp. 225–241.

Summary of results of duty of water experiments on field crops made in 1901.

Crop.	Area irrigated.	Yield per acre.	Number of irrigations.	Rainfall.	Depth applied.
	Acres.			*Foot.*	*Feet.*
Clover[a]	20.86	3.36 tons	2	0.65	0.92
Do	5.59		3	.67	1.81
Do	7.13		2	.62	1.24
Do	6.85		3	.62	1.55
Wheat[a]	5.25	43.20 bushels	2	.45	1.20
Do	3.00	42.90 bushels	2	.43	.77
Barley[a]		61.50 bushels			
Clover[a]		1.59 tons			
Sugar beets[a]	1.00	10 tons	3	.59	1.46
Oats[a]	15.35	73 bushels	2	.43	1.63
Clover[a]	27.84	3 tons	1	.62	.95
Barley[a]	12.47	59 bushels	1	.46	.85
Peas[a]	8.41	37.50 bushels	1	.77	.35
Oats[a]	37.30		1	.45	1.27
Orchard[b]	40.00		4	.49	1.56
Clover[b]	161.70	0.90 ton	3	.49	1.50
Do	102.00	1 ton	4	.45	2.22
Alfalfa[c]	53.41			.59	1.14

[a] Gallatin County. [b] Ravalli County. [c] Yellowstone County.

MEASUREMENTS MADE IN 1902.

In beginning the field tests in the spring of 1902, advantage was taken of the weir boxes already in place, which had been used in previous years. On account of the long season, the spring being early and a plentiful supply of water in the streams, more water was used. In Gallatin County three crops of clover and one crop of alfalfa received on an average for all four crops 20.8 inches of ditch water and 9.4 inches of rain water, while five grain crops received 18 inches from irrigation and 7.4 inches from rainfall.

In Ravalli County a record was kept of the amount of water applied to each of the fields previously described, and the average is considerably higher, being for the three fields 28.1 inches of irrigation water and 7.9 inches of rain water.

Summary of results of duty of water experiments on field crops made in 1902.[a]

Crop.	Area irrigated.	Number of irrigations.	Rainfall.	Depth applied.
	Acres.		*Foot.*	*Feet.*
Barley[b]	19.80	2	0.64	0.97
Rotation plats[b]	6.00	2	.64	1.04
Wheat[b]	5.62	2	.72	2.44
Oats[b]	3.38	2	.54	1.28
Clover[b]	9.72	2	.78	1.65
Oats[b]	8.93	2	.54	1.77
Alfalfa[b]	4.02	2	.78	1.00
Clover[b]	27.84	1	.78	1.00
Do[b]	81.30		.78	3.13
Orchard[c]	40.00		.66	1.77
Clover[c]	161.00		.66	1.30
Do[c]	102.00		.66	3.95

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 133, pp. 137-150.
[b] Gallatin County.
[c] Ravalli County.

MEASUREMENTS MADE IN 1903.

During the season the flow of a large number of canals was measured for the purpose of ascertaining the duty of water under each, but few results were obtained from fields. The depth of water applied to a clover field in the Gallatin Valley, owned by Mr. J. L. Patterson, was 11.2 inches. Another clover field in the same valley, owned by Mr. John M. Robinson, received a depth of 20.2 inches. A third field of timothy and clover, owned by State Senator C. W. Hoffman, received in one irrigation a depth of 7.9 inches.

In the Bitter Root Valley a clover field received a depth of 16.4 inches. The yield was 1.94 tons per acre. A second clover field located on the Bitter Root stock farm received 94.1 inches, yet the yield was only 2.04 tons per acre, or a trifle more than that of the field where only about one-sixth the amount of water had been used.

Summary of results of duty of water experiments on field crops made in 1903.

Crop.	Area irrigated.	Yield per acre.	Number of irrigations.	Rainfall.	Depth applied.
	Acres.	*Tons.*		*Feet.*	*Feet.*
Clover	27.84	....	1	1.03	0.94
Do	81.30	....	1	1.03	1.69
Timothy and clover	37.33	....	1	1.03	.66
Clover	161.70	1.91	2	.40	1.37
Do	102.00	2.04	4	.40	7.84

QUANTITY OF WATER APPLIED TO LAND UNDER TYPICAL CANALS.

The quantity of water diverted by canals is in all but the most exceptional cases much larger than that delivered by it to fields. This difference is due to losses by percolation and evaporation. In addition to the losses water is frequently allowed to flow from the canals over waste ways. This water may return to the natural channel of the stream, or it may be wasted. In the spring of the year when water is plentiful many Montana canals carry an excess which is permitted to flow through waste gates unutilized. The same is true of the period near the close of the irrigation season or during a rainy spell. At such times more water is turned in at the head than the farmers care to use. In determining the duty of water under a canal it is customary to measure the flow daily at some suitable place near the head gate and to consider the volume which passes this point in the season in determining the duty of water for that particular canal. Losses due to the causes just named may be determined and an allowance made for them; but these will be considered under the term "seepage" in another part of this report. In the statement of duty of water under canals contained herein no deduction has been made for any of the losses just named.

THE BIG DITCH OF YELLOWSTONE COUNTY.

Yellowstone County, lying between the Musselshell River on the north and the Yellowstone River on the south, contains about 2,370,000 acres, a large part of which is arable. The Yellowstone River is the chief source of water, but owing to the difference in elevation between the large part of the arable land and the stream, which has a somewhat low grade for at least 100 miles above, only a portion of the arable land can be reached. At the present time the reclaimed land is found in the valleys bordering the river and separated from the higher bench lands by high walls of stratified sand rock.

The Big ditch is the largest one in the county and one of the largest in the State. Its capacity in 1903, as compared with the principal canals in this county, may be seen from the results of discharge measurements made in 1903, and given below:

Discharge of Yellowstone County ditches.

	Cubic feet per second.
Big ditch	383
Canyon Creek ditch	60
Italian ditch	56
Yellowstone ditch	36
Merril ditch	31
Mill ditch	29
Flaherty Flat ditch	22

It was completed over twenty years ago at a cost of $110,000, but the area irrigated was quite small for the first few years. It was maintained and operated by an investment company until May, 1900, when it was purchased by the farmers who owned land under it, and became a cooperative canal. It is managed by a board of trustees annually elected by the stockholders from among their number. The price paid was $64,000, which was divided into shares of the par value of $10 each. In 1902 there were 132 stockholders whose shares varied in number from 1 to 385 and averaged 47 shares each. In July, 1904, the number of stockholders had increased to 158, and the maximum number of shares held by one man decreased to 377.

Prior to 1900 little was known of the capacities of any of the Yellowstone County ditches, or of the duty of water under them. The flow was supposed to be divided among the water-right owners in miner's inches, but the prevalent idea regarding a miner's inch was one of about double the discharge of the statutory inch. In the spring of that year three measuring stations were established on the Big ditch and a daily record kept of the flow at each from May 25 to September 27. The first of these stations was at Tilden's ranch, about 5 miles below the head gates on Yellowstone River, the second at Park City, and the third at the Hesper farm, located 11 and 27 miles, respectively, below the head gates. There were no diversions above Tilden's ranch. The canal terminated on the bench above the town of Billings, the total length being 39 miles.

The extent of land irrigated under the Big ditch was ascertained in 1901 and 1902 by a house-to-house canvass, but during the summer of 1903 a survey was made of each farm irrigated from the canal. Inasmuch as the irrigated area, as determined by the survey in 1903, was somewhat less than that of previous years, the latter may have been overestimated. On the other hand, there is a possibility that less land was irrigated in 1903. As will be seen from the following table, alfalfa is the prevailing crop, and meadow land, which comprises timothy and blue joint, as well as irrigated pasture, ranks second.

Acreage of crops irrigated under Big ditch for the years named.

	1901.	1902.	1903.		1901.	1902.	1903.
	Acres.	*Acres.*	*Acres.*		*Acres.*	*Acres.*	*Acres.*
Alfalfa	8,270	8,891	8,383	Garden	550	610	615
Meadow	6,309	6,243	3,664	Corn	352	358	169
Oats	1,885	3,117	3,401				
Wheat	778	816	913	Total	18,144	20,038	17,145

The daily measurements of discharge begun in 1900 have been continued for four years, and the results of measurements made at Tilden's ranch are summarized in the following table, together with the depths to which this would cover the land irrigated:

Discharge of Big ditch at Tilden's ranch for 1900 to 1903, inclusive.

Month.	1900, discharge.	1901.		1902.		1903.	
		Discharge.	Depth.	Discharge.	Depth.	Discharge.	Depth.
	Acre-feet.	*Acre-feet.*	*Feet.*	*Acre-feet.*	*Feet.*	*Acre-feet.*	*Feet.*
May	2,193	6,212	0.34	10,198	0.51	682	0.04
June	14,643	9,980	.55	15,580	.78	10,647	.62
July	13,317	16,243	.90	19,135	.95	21,475	1.25
August	9,991	14,070	.78	17,469	.87	9,577	.56
September	6,852			11,443	.57	16,454	.96
October						11,772	.69
Total	46,996	46,505	2.56	73,825	3.68	70,607	4.12

It will be seen from the foregoing statement that the volumes used in 1900 and 1901 are about equal, but that a large increase occurred in 1902 and 1903. This is due to improvements and enlargements. In order to expedite this work no water was run in the canal during the month of September, 1901. There is an apparent decrease in the volume carried in 1903 over that of the preceding year, but this is due to two shut downs, the first of which lasted from May 14 to May 31, and the second from July 27 to August 17. As a matter of fact, the maximum volume carried in 1903 exceeded that of 1902 by nearly 25 per cent.

The diagram (fig. 10) illustrates the daily flow of the Big ditch in 1903, and the average quantity of water which was applied to the land each month of the irrigating season. The ditch was closed for repairs from June 14 to July 1 and from July 26 to August 17, which greatly reduced the amounts of water applied to land in June and August.

Considering that alfalfa and meadow lands, both of which require large amounts of water, were the principal crops, and that a large percentage of the water taken from the river was either lost in transit or permitted to flow through waste ways unutilized, the conclusion is justified that one-half of a miner's inch per acre is a fair average for the duty of water in Yellowstone County. Yellowstone County in climate, products, and physical characteristics is similar to much of the land bordering on the Yellowstone River. One may, therefore, go further and state that as an average one-half a miner's inch of water per acre will suffice for the counties of Park, Yellowstone, Sweet Grass, Carbon, Rosebud, Custer, Dawson, and the Crow Reservation, or a total of 2,925,000.

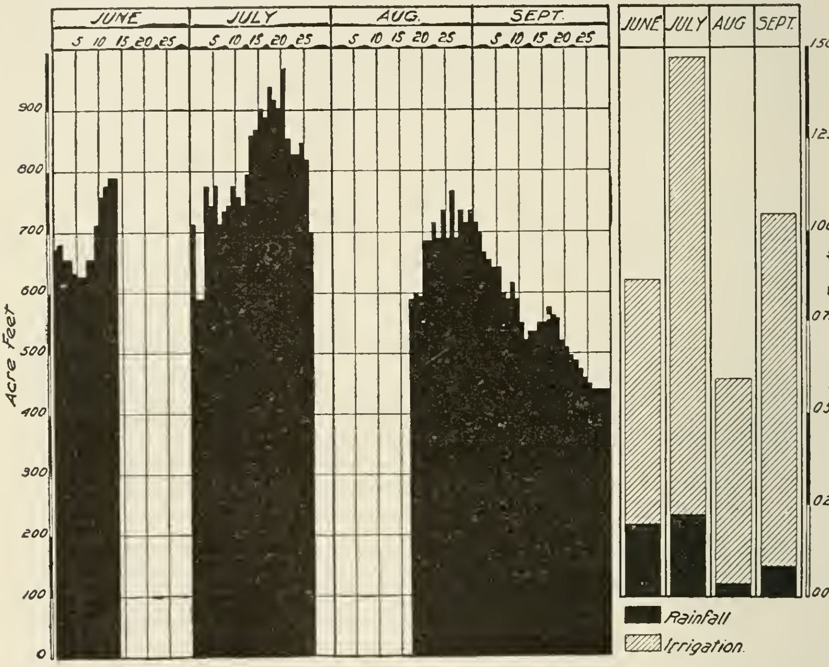

FIG. 10.—Daily discharge of Big ditch, and depths of water received by lands thereunder, 1903.

CANALS OF GALLATIN COUNTY

MIDDLE CREEK CANAL.

Middle Creek canal is the largest of some thirteen ditches which divert water from Middle Creek, a tributary of the Gallatin River. The summer flow of this creek (see p. 25) is wholly diverted and utilized to irrigate farms located in the upper or southeastern part of Gallatin Valley. The top layer of soil in this section consists of rich vegetable loam. In the most fertile portions this vegetable loam gradually changes into clay loam and clay marl but in other portions the coarse gravel and cobbles which underlie all are found within a foot of the surface. Considerable rain and soft snow fall in April, May, and June of each year, and in moderately wet springs this is sufficient for the needs of the crops until about July 1. In other years, when the spring crops are seeded early, or when the weather is warm and dry, water is applied in June and occasionally in May to meadows.

The grade of Middle Creek, particularly at the upper end, is excessive. In a total length of 18,000 feet the fall is 170 feet, or on an average of nearly 50 feet per mile. Owing to the high velocity, the channel is washed clean of all earth and fine sand, and only coarse gravel and cobbles remain. The loss by seepage is thus large in proportion to the volume carried (see p. 95). Notwithstanding this heavy loss, the duty of water as measured during the past five years has been reasonably high. The rating flume at which water measurements have been made is located about 200 feet below the intake, so that all losses in transmission are included. This record is valuable in that it extended through a period of five consecutive years, which included seasons of scanty as well as seasons of abundant rainfall. Compared with average amounts used in other parts of Gallatin Valley and other parts of the State, this duty is high, being at the rate of 1 miner's inch for nearly 3 acres of land. At the same time the yield and value of the crops under Middle Creek canal have not appeared to suffer in the least on account of the small quantity of water used, since for the period under consideration they have been fully equal to those of other sections of Gallatin Valley and superior to those of many other parts of the State.

Barley and hay are the principal crops under this canal. Some ten or fifteen years ago little but grain was raised, and in order to increase the diminishing yields recourse was had to summer fallowing. A field which produced barley, wheat, or oats for one or two years was summer fallowed for one season and then replanted to grain. Largely through the efforts of the Montana Experiment Station this wasteful method of irrigated farming was changed to one of scientific rotation. It was demonstrated repeatedly that better crops were obtained after red clover than after summer fallowing, and in consequence much of the land which remained idle every alternate year is now producing red clover or alfalfa. It was likewise shown by the same agency that the climate and soil of Gallatin Valley were peculiarly adapted to the growth of brewing barley, which accounts for the large acreage in this crop.

Acreage of irrigated crops under Middle Creek canal for 1899.

	Acres.
Barley	1,438
Oats	597
Wheat	118
Timothy and clover	1,405
Clover and alfalfa	147
Other crops	148
Total	3,853

The areas watered were: 1899, 3,853 acres; 1900, 3,853 acres; 1901, 3,168 acres; 1902, 4,828 acres; 1903, 4,828 acres.

Duty of water under Middle Creek canal for the years 1899, 1900, 1901, 1902, and 1903.[a]

Month.	1899.		1900.		1901.		1902.		1903.	
	Discharge.	Depth.	Discharge.	Depth.	Discharge.	Depth.	Discharge.	Depth.	Discharge.	Depth.
	Acre-ft.	*Feet.*	*Acre-ft.*	*Feet.*	*Acre-ft.*	*Feet.*	*Acre-ft.*	*Feet.*	*Acre-ft.*	*Feet.*
May	....	....	....	....	....	....	263	0.05	....	....
June	1,539	0.40	3,917	1.01	2,222	0.70	3,091	.64	2,898	0.60
July	4,610	1.20	1,912	.50	2,973	.93	1,363	.28	1,515	.31
August	903	.23	1,075	.28	1,541	.48	857	.18	1,523	.32
September	1,022	.27	420	.11	718	.22	....	....	1,201	.25
Total	8,074	2.10	7,324	1.90	7,454	2.33	5,577	1.15	7,137	1.48

[a] See diagram, fig. 11.

OTHER CANALS FROM MIDDLE CREEK.

Besides the Middle Creek canal there are 12 smaller ditches, which tap the same source. These 13 ditches divert the entire flow of Middle Creek after the spring flood has subsided. The maximum flow occurs from March 10 to June 20 of each year. When the highest water occurs in the second week of June the daily decrease in the stream is so great that all the flow is utilized before July 1, but when it occurs as late as the third week in June there may be an excess of water which is discharged into the East Gallatin and from thence into the Missouri River during the first week in July. As a rule, however, there is no surplus after July 1.

The following figures on the summer flow of Middle Creek have been computed chiefly from measurements made by the United States Geological Survey at the mouth of Middle Creek Canyon and about 1 mile above the highest ditch which diverts water for irrigation.

Monthly discharge in acre-feet of Middle Creek for the years named.

Month.	1898.	1899.	1900.	1902.
May	16,610	8,150	....	6,150
June	25,521	29,982	5,750	13,250
July	10,586	20,559	5,500	7,115
August	3,989	6,383	3,460	3,662
September	3,178	3,414	2,870	2,970
October	2,255	2,987	1,240	304
Total	62,139	71,475	18,820	33,451

During the summer of 1902 the acreage of crops irrigated under Middle Creek was ascertained by a plane-table survey. For convenience and to lessen the expense the crops were grouped. Thus all the cereals, such as barley, wheat, and oats, were included under the general term of grain crops; alfalfa, clover, timothy, and forage crops generally were grouped under hay crops; irrigated pasture lands formed a third group; vegetables, root crops, and orchards were included under garden crops, and all summer-fallowed land was kept separate from cropped areas.

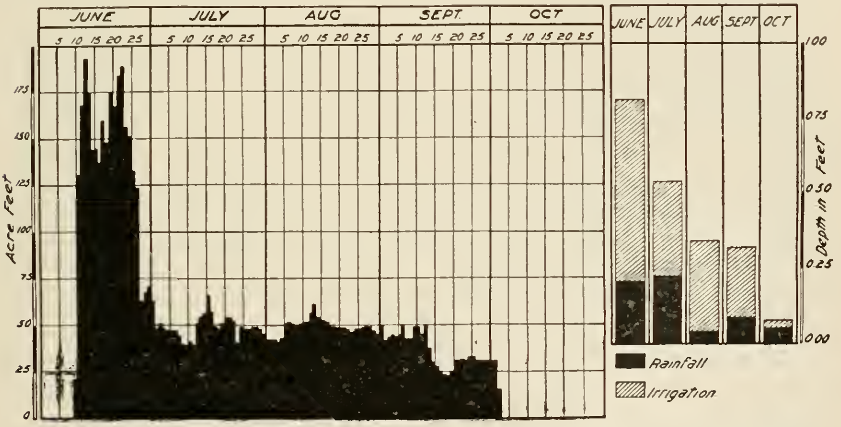

FIG. 11.—Daily discharge of Middle Creek canal, and depth of water received by land, 1903.

Acreage of crops irrigated by 13 ditches diverting water from Middle Creek in 1902.

	Acres.
Grain	2,944
Hay	5,284
Pasture	678
Garden	62
Total	8,986
Area in summer fallow	1,366
Total cultivated area	10,334

In computing the duty of water under Middle Creek for the season of 1902 the amounts used in July, August, and September were accurately determined, since the entire flow of the stream was diverted during these three months. In June, however, there was a surplus which was not measured, and for that month the duty is estimated as follows: The total discharge for June was 13,250 acre-feet and for July 7,115 acre-feet. As a rule, more water is used on the Middle Creek farms in July than in June, but in arriving at the estimate the utilized flow during June was made equal to that during July. The duty of water for the season, as expressed in the following table, thus becomes 2.33 feet in depth over the surface of 8,968 acres, which corresponds to the continuous flow of 1 cubic foot per second for 104 acres, or of 1 miner's inch for 2.1 acres.

Duty of water under Middle Creek for the year 1902, June to September, inclusive.

Area irrigated	acres	8,968
Water used	acre-feet	20,862
Depth	feet	2.33
Acres per cubic foot per second		104
Acres per miner's inch		2.60

WEST GALLATIN IRRIGATION COMPANY'S CANAL.

This canal, which is one of the largest in Gallatin County, gets its supply from the West Gallatin River. The intake is located at the mouth of the canyon, and from this point the canal winds around the river bluffs in a northwesterly direction for about 40 miles. The formation varies from a loose vegetable loam on top to sand, gravel, and bowlders beneath, overlying a soft sand rock. The softer portions of this sand rock are readily disintegrated by seepage water from the canal, and whenever the top of this stratum coincides with the bottom of the excavated canal, it is difficult to prevent water from percolating between the subsoil and this rock stratum. These unfavorable conditions have caused a number of bad breaks in the upper portion of the canal. The losses due to seepage on the main canal, described elsewhere (see p. 93), form about one-third of the total volume admitted at the intake. Small additional losses occur along the lines of the various laterals. Then, too, much of the land under this canal is undulating, with steep slopes cut up by ravines, and in attempting to spread water over the surface more or less runs off and serves no useful purpose. These physical conditions, coupled with a somewhat porous soil and crude methods of irrigation, account for the large quantity of water which was applied to land under this canal in 1902. The area irrigated was 2,343 acres.

Duty of water under West Gallatin Irrigation Company's canal for 1902.

Month.	Discharge.	Depth.
	Acre-feet.	*Feet.*
May	569	0.24
June	3,613	1.54
July	5,555	2.37
August	2,729	1.17
Total	12,466	5.32

KUGHEN OR CAMERON CANAL.

This canal is one out of fifty-four which divert water from the West Gallatin River. It is owned and controlled by a small community of farmers, whose farms are located in the upper portion of the central belt of Gallatin Valley. Of the canals which take water from the left or west bank of the river it ranks next in capacity to the West Gallatin Irrigation Company's canal. It is nearly 11 miles long, has a bottom width of 11 to 12 feet, and a depth of 2 to 3 feet near the head and is capable of carrying some 80 cubic feet of water per second. The losses due to seepage are small. At the same time, the duty of water is low. This is largely due to the fact that this ditch possesses one of the oldest rights on the river, and has recently been enlarged to carry an abundant supply for the comparatively small area of land which it irrigates, much more in fact than the crops require.

The crops irrigated in 1902 are shown in the following table:

Acreage of irrigated crops under the Kughen canal for 1902.

	Acres.
Barley	899
Oats	423
Flax	122
Timothy	80
Pasture	25
Wheat	12
Clover	3
Total	1,564

During the same year 1,379 acres, or nearly one-half the total cultivated area was summer fallowed. If the excess water which was wasted in irrigating 1,564 acres had been applied to the 1,379 acres of fallow land, the additional yield in 1902 from the thirteen farms under this canal would have, in all probability, had a gross value of $27,000.

The discharge of the ditch and the depth to which it would cover the land are shown in the following table:

Duty of water under the Kughen canal in 1902 and 1903.

Month.	1902.		1903.	
	Discharge.	Depth.	Discharge.	Depth.[a]
	Acre-feet.	*Feet.*	*Acre-feet.*	*Feet.*
June	2,643	1.69	1,985	1.27
July	3,604	2.30	3,862	2.47
August	1,079	.69	1,712	1.09
September			1,488	.95
Total	7,326	4.68	9,017	5.78

[a] The area irrigated in 1903 is assumed to be the same as in 1902.

Figure 12 shows the flow of this canal in 1903 and likewise the amounts of water applied to the land during each month.

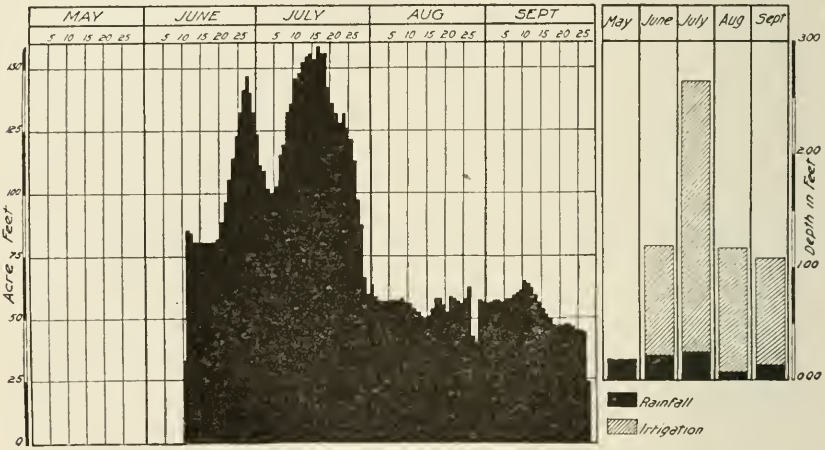

FIG. 12.—Daily discharge of Kughen canal, and depth of water received by land, 1903.

CANALS OF RAVALLI COUNTY.

The land of Ravalli County, which contains in round numbers 1,850,000 acres, may be divided into three classes. The western and to a considerable extent the southern part of the county is well timbered and mountainous. Through the central portion flows the Bitter Root River, on either side of which are to be found large tracts of arable and irrigable land, and in the east the land is undulating and hilly and chiefly devoted to grazing. On the west of the Bitter Root River, which flows north to meet the Missoula, the dense groves of pines, firs, and tamaracks extend from the borders of the valley and in many places from the river bank to the summit of the Bitter Root Range, from 10 to 15 miles distant. On this steep mountain slope, which rises at times 5,000 feet in 5 miles, the green of the pines makes a vivid contrast with the snow-capped peaks of the range, which rise to heights of 9,000 to 10,000 feet. At the foot of this forest slope is a typical mountain stream, the water of which, except in flood time, is unusually clear. Throughout the long valley diversified farming is practiced. All kinds of cereals do well. Red clover and timothy seem to be preferred in places to alfalfa. The soil is peculiarly well adapted to vegetables, and both soil and climate are admirably suited to fruit raising. The apple, plum, cherry, and in fact all the hardier varieties of deciduous fruit trees appear to have found in the Bitter Root Valley ideal conditions for their growth. Sheltered from the west winds by the Bitter Root Mountains and from the east winds by the main range of the Rockies, the valley possesses a much more moderate climate than many fruit-producing regions which lie far to the south of Montana. The altitude is low compared with much of the irrigated portion of the West, being about 3,200 feet above sea level at the lower end and rising to 3,800 feet at the upper end. The granite soil is light and porous, with a large percentage of sand and gravel. In the lower valleys the soil is frequently a rich vegetable loam, and to the east of the river there are large tracts of heavier soils containing more or less clay. The land to the west of the river is abundantly supplied with water. Numerous creeks, which are fed by the heavy snowfall of the Bitter Root Range and forest reserve, are easily diverted by short ditches. As may be expected, the duty of water throughout this part of the valley is low. The soil is porous and underlaid by a mass of rock débris from the mountains, so that any excess of water which may be applied soon returns to the main channel of the stream without producing, it is thought, any injurious effects upon the soil.

East of the river conditions are different. The mountains to the east being low, the precipitation, particularly in the form of snow, is light, and in consequence there are few creeks in this part of the basin. Yet on this side the larger tracts of fertile lands are located, and for their irrigation water has been conveyed from the Bitter Root River in canals of considerable size. The most of these canals were begun by small communities of farmers in the eighties, and the majority are still maintained and operated by the landowners and water users under them. Other canals that were begun during the early development of this part of the State have passed into the hands of capitalists.

In 1900 advantage was taken of this large tract of irrigated land and its excellent system of irrigation canals to gain more knowledge concerning the use of water in irrigation and the seepage losses from canals. The investigations then begun have continued since, and during the entire period the Office of Experiment Stations and the Montana Experiment Station have been greatly assisted by the officers of the Bitter Root stock farm. The irrigation system was intended to cover more land than has since been irrigated, and the water supply is ample, so that the economical use of water has never been a necessity. Another cause for low duty is the large area of new land which has been recently brought under irrigation, requiring an additional amount of water. And, finally, much of the land is porous, gravelly soil on elevated benches, with more or less ravines and steep slopes. The results obtained under such conditions should represent the maximum use in Montana.

REPUBLICAN CANAL.

This canal was begun by farmers in the vicinity of what is now the city of Hamilton, the county seat of Ravalli County. In 1889 the stockholders changed the point of diversion and the source of supply on Skalkaho Creek to the Bitter Root River near the junction of the tributary known as Sleeping Child.

The area of land irrigated was determined by actual survey. The areas irrigated were, in 1901, 4,105 acres; in 1902, 4,850 acres; and in 1903, 4,850 acres. The manner in which this area was utilized in 1903 to raise the standard crops is shown in the following table:

Acreage of crops irrigated under Republican canal in 1903. [a]

	Acres.
Wheat	201
Oats	210
Pasture	681
Meadow	758
Peas	6
Roots and vegetables	20
Orchards	61
Total	1,937

In the following table are given the volumes discharged by the canal in acre-feet for each month of the irrigation season for the years 1901, 1902, and 1903, with the depths to which this would cover the total irrigated area:

Duty of water under Republican canal for the years 1901, 1902, and 1903.

Month.	1901.		1902.		1903.	
	Discharge.	Depth.	Discharge.	Depth.	Discharge.	Depth.
	Acre-feet.	*Feet.*	*Acre-feet.*	*Feet.*	*Acre-feet.*	*Feet.*
April	1,608	0.39				
May	3,115	.76	3,442	0.71	3,043	0.63
June	2,116	.52	4,372	.90	3,852	.80
July	3,656	.89	3,995	.82	2,810	.58
August	3,263	.79	5,826	1.20	2,602	.54
September			4,251	.88	1,940	.40
Total	13,758	3.35	21,886	4.51	14,247	2.95

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[a] Exclusive of Patterson laterals and outside water users.

Figure 13 shows the daily flow of the Republican canal in acre-feet during the season of 1903, and also the depth of water received by the land each month.

SKALKAHO CANAL.

This canal was built for the purpose of irrigating about 2,000 acres of land located above the Ward canal. It is 7 miles long, and over one-third of this distance the water is carried in either a wooden flume or redwood-stave siphon. The siphon is 36 inches in diameter and the flume has a sectional area of 12.5 square feet. On a grade of 0.1 foot to the hundred feet the mean velocity is about 5 feet per second, thus producing a maximum discharge of over 60 cubic feet per second. Sixteen hundred acres were irrigated in 1901, and 1,975 acres in 1902 and 1903. The monthly discharge and depths to which this would cover the land is given below:

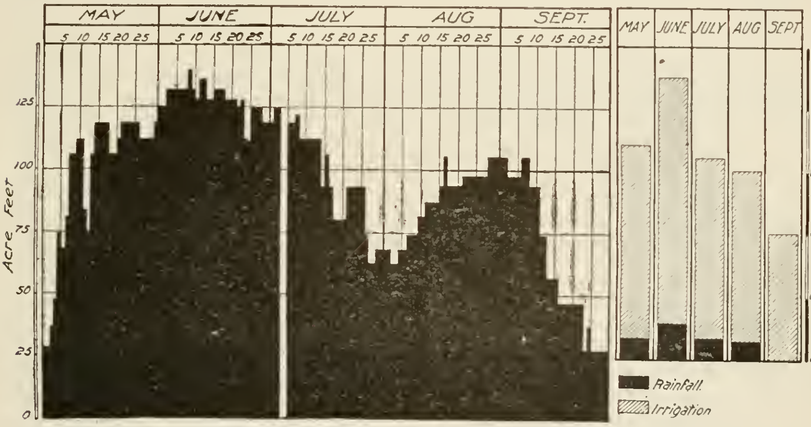

FIG. 13.—Daily discharge of Republican canal, 1903, and depth of water received by land.

Duty of water under Skalkaho canal for 1901, 1902, and 1903.

Month.	1901.		1902.		1903.	
	Discharge.	Depth.	Discharge.	Depth.	Discharge.	Depth.
	Acre-feet.	*Feet.*	*Acre-feet.*	*Feet.*	*Acre-feet.*	*Feet.*
April	506	0.32	469	0.24	490	0.25
May	1,775	1.11	2,097	1.06	1,936	.98
June	1,477	.92	3,336	1.69	3,040	1.54
July	2,290	1.43	3,335	1.69	3,308	1.67
August	1,447	.90	2,582	1.31	2,314	1.12
September			1,618	.82	1,542	.98
Total	7,495	4.68	13,437	6.61	12,630	6.34

GIRD CREEK DITCHES.

The waters of Gird Creek, which flow from the mountains on the east side of the Bitter Root Valley, are diverted on the lands of the Bitter Root stock farm by three canals. One diverts water to the south and the water is mixed with that from the Skalkaho canal; the other two carry water to the bench north of Gird Creek, and are known respectively as the Old Gird canal north and the New Gird Creek canal north. The monthly discharge of the Gird Creek canals is as follows:

Monthly discharge of Gird Creek canals for 1901, 1902, and 1903.

Month.	1901.	1902.	1903.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*
April	....	291	240
May	....	1,998	2,163
June	....	3,653	4,592
July	....	2,833	3,756
August	....	3,293	3,240
September	....	1,492	1,597
Total	1,759	13,560	15,583

Considering the Gird Creek ditches and the Skalkaho canal together gives the following statement of duty for 1903:

Duty of water under Gird Creek ditches and Skalkaho ditch for 1903.

Area irrigated	acres..	3,320
Water used	acre-feet..	28,218
Depth over surface	feet..	8.50

WARD CANAL.

The Ward canal diverts water from Skalkaho Creek, a tributary of the Bitter Root. It is the third in elevation of the five canals operated by the Ravalli Land and Irrigation Company. It is 7 miles long, has a capacity of about 70 cubic feet per second, and waters 3,985 acres. The areas devoted to the various crops in 1903, so far as could be learned, were as follows:

Acreage of crops irrigated under Ward canal in 1903.

	Acres.
Meadow	849
Oats	573.3
Wheat	102
Roots and vegetables	14.8
Orchards	33
Pasture	383.6

The monthly discharges and the depths on the land are given in the following table:

Discharge of the Ward canal for 1901, 1902, and 1903.

Month.	1901.		1902.		1903.	
	Discharge.	Depth.	Discharge.	Depth.	Discharge.	Depth.
	Acre-feet.	*Feet.*	*Acre-feet.*	*Feet.*	*Acre-feet.*	*Feet.*
April	591	0.16	230	0.06	....	....
May	3,009	.81	2,318	.58	1,852	0.46
June	2,529	.71	3,752	.94	4,424	1.11
July	2,059	.57	2,566	.65	2,771	.70
August	438	.12	807	.20	844	.21
September	....	....	253	.06	345	.09
Total	8,626	2.40	9,926	2.49	10,236	2.57

Figure 14 shows the use of water under the Ward canal in 1903.

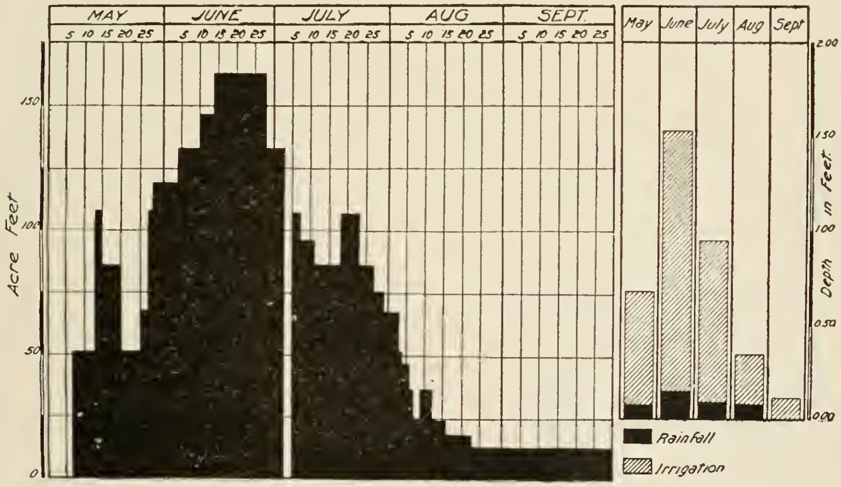

FIG. 14.—Daily discharge of Ward canal, 1903, and depth of water received by land.

HEDGE CANAL.

The Hedge canal diverts water from the Bitter Root River about 35 miles above the Republican canal. The original ditch of this name was built by Mr. Hedge for the purpose of diverting water from Skalkaho Creek, but Mr. Daly, after purchasing the rights of Mr. Hedge, extended the canal up the valley by means of flumes to tap the Bitter Root. There are about 5 miles of flumes on this canal, and two ravines are crossed by means of redwood-stave pipe laid in the form of an inverted siphon. This canal is 24 miles long, has a capacity of over 200 acre-feet per day, and waters over 5,000 acres. The areas irrigated in 1901, 1902, and 1903 were 5,260 acres, 5,420 acres, and 5,420 acres, respectively.

The results of surveys made in 1903 to determine the areas under this canal which were devoted to particular crops are included in the table given below.

Acreage of crops irrigated under Hedge canal in 1903.

	Acres.
Meadow	1,267
Oats	549
Wheat	83
Roots and vegetables	9.6
Orchards	58.5
Pasture	463
Total	2,430.1

The monthly discharge of the canal and the depths to which it would cover the land served are given in the following table:

Duty of water under Hedge canal for 1901, 1902, and 1903.

Month.	1901.		1902.		1903.	
	Discharge.	Depth.	Discharge.	Depth.	Discharge.	Depth.
	Acre-feet.	*Feet.*	*Acre-feet.*	*Feet.*	*Acre-feet.*	*Feet.*
April	2,194	0.42	1,722	0.32		
May	4,431	.84	5,439	1.00	2,514	0.46
June	3,302	.63	6,243	1.15	6,249	1.15
July	5,573	1.06	5,955	1.10	4,120	.76
August	5,382	1.02	6,277	1.16	4,744	.88
September			5,626	1.04	5,183	.96
Total	20,882	3.97	31,262	5.77	22,810	4.21

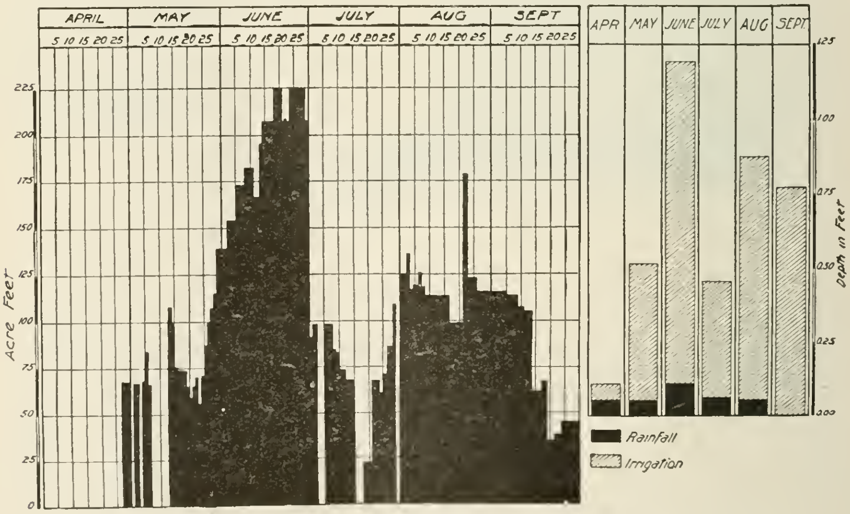

FIG. 15.—Daily discharge of Hedge canal, 1903, and depth of water received by land.

Figure 15 illustrates the use of water under the Hedge canal in 1903.

Until the year 1903 all the experiments on the duty of water in the Bitter Root Valley were conducted on the Bitter Root stock farm. This tract occupies the middle portion of the valley. In order to obtain a fair test for the entire valley three other tracts of land were selected in other sections of the valley.

HARLAN DITCH.

The Harlan ditch diverts water from the Bitter Root River near the Como bridge and carries water to the farm of Mr. W. B. Harlan. This farm consists of a gravel and sand wash from a canyon entering the valley from the east. The area irrigated was 83 acres. The water was measured near the upper end and a small loss was sustained in transmission and 25 per cent was wasted at the lower side of the farm. The discharges given below are 25 per cent less than those shown by the measurements:

Duty of water under W. B. Harlan's ditch for the season of 1903.

Month.	Discharge.	Depth.
	Acre-feet.	*Feet*
May	170	2.05
June	232	2.80
July	162	1.95
August	92	1.11
Total	656	7.91

BASS BROTHERS' DITCH.

Bass Brothers' ditch diverts water from a small stream of the same name which is a tributary of the Bitter Root River. This ditch irrigates about 400 acres of very fertile land on the west side of the Bitter Root River about 5 miles northwest from Stevensville. The soil of this farm is a compound of decomposed granite and vegetation, with some sand and gravel. It is about 2 feet deep and slopes quite rapidly toward the middle of the valley.

On May 26, 1903, a rating flume was placed in the ditch as it enters the field. The record of gauge height was kept by an automatic register. There were no seepage losses of noticeable quantity. The monthly discharge and the depth of irrigation are given in the following table:

Duty of water under Bass Brothers' ditch for the season of 1903.

Month.	Discharge.	Depth.
	Acre-feet.	*Feet.*
May	67.76	0.169
June	254.63	.636
July	156.70	.392
August	118.61	.296
Total	597.70	1.490

The areas in the various crops were as follows:

Acreage of crops irrigated under Bass Brothers' ditch for the season of 1903.

	Acres.
Timothy and clover	175
Orchard	85
Wheat	30
Oats	10
Peas and garden	10
Pasture	90
Total	400

Figure 16 illustrates the use of water under Bass Brothers' ditch in 1903.

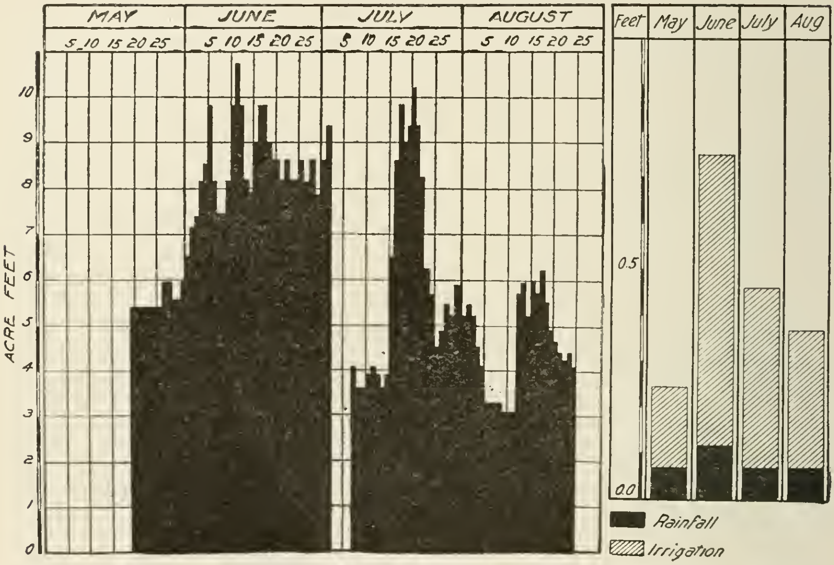

Fig. 16.—Daily discharge of Bass Brothers ditch, 1903, and depth of water received by land.

ALLEN, HUGHES, ET AL. DITCH.

This ditch takes its waters from Lolo Creek near the mouth of the Bitter Root Valley, and on the west side of the river. The land covered is a delta or wash from the Lolo Canyon, and is composed of a gravel and sandy loam underlaid by a deep bed of gravel. This drinks up the water rapidly, and the ground is solid and firm in a very short time after the irrigation. The climate and soil in this locality are particularly well adapted to fruit growing, and all the varieties of apples, pears, plums, and berries, with some very fine peaches, grow well. On May 28, 1903, a rating flume with automatic register was placed in the ditch at the upper edge of the field and there was no loss by seepage. The area watered was 247.6 acres.

The monthly discharge and the depth are given in the following table (fig. 17):

Duty of water under Allen, Hughes, et al. ditch for season of 1903.

Month.	Discharge.	Depth.
	Acre-feet.	*Feet.*
May	20.62	0.08
June	611.60	2.46
July	344.92	1.39
August	613.68	2.47
Total	1,590.82	6.40

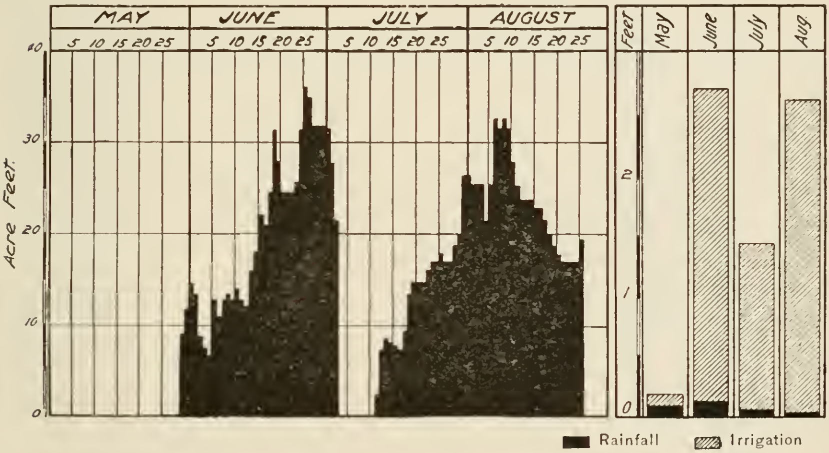

FIG. 17.—Daily discharge of Allen, Hughes, et al. ditch, 1903, and depth of water received by land.

The following table shows the acreage of different crops:

Acreage of crops irrigated under Allen, Hughes, et al. ditch in the season of 1903.

	Acres.
Orchard	91.6
Clover	76.5
Timothy	51
Oats	20
Garden	5
Potatoes	1.5
Corn	1
Beets	1
Total	247.6

All measurements of depth of water to which the water diverted by canals would cover the land irrigated by them, disregarding losses in transit are brought together in the following table:

Summary of the duty of water measurements in Montana.

County.	Canal.	Year.	Depth.
			Feet.
Gallatin	West Gallatin high line	1902	5.32
Do	Kughen or Cameron	1902	4.68
Do	do	1903	5.78
Do	Weaver & Stone	1902	5.56
Do	Middle Creek canal	1899	2.10
		1900	1.90
		1901	2.33
		1902	1.15
		1903	1.48
Do	Middle Creek (all canals)	1902.	2.60
Do	West Gallatin Irrigation Co	1902	5.32
Yellowstone	Big ditch	1901	2.56
		1902	3.68
		1903	4.12
Ravalli	Republican	1901	3.35
		1902	4.51
		1903	2.95
Do	Skalkaho	1901	4.68
		1902	6.81
		1903	6.34
Do	Gird Creek and Skalkaho	1903	8.50
Do	Ward	1901	2.40
		1902	2.49
		1903	2.57
Do	Hedge	1901	3.97
		1902	5.77
		1903	4.21
Do	Harlan	1903	7.91
Do	Bass Brothers	1903	1.49
Do	Allen, Hughes, et al	1903	6.40
	Average		4.10

DUTY OF WATER IN COURT DECREES IN MONTANA.

Since the rights to the use of water can be determined only by the courts as the result of litigation, and since water is the chief factor in the agricultural development of the State, it may add to the value of this report to review some of the decisions of these tribunals in which parties have been granted rights to the use of fixed volumes of water from the public streams. Only a small percentage of the total number of people who use water have had their rights thus defined, but in every county where irrigation has been practiced for some time controversies over water have arisen and the majority of these controversies have culminated in court decisions which are on file in the recording offices of the respective counties. Some of these decisions are so indefinite as to possess little, if any, value in a discussion of this character. One party, for example, may be decreed a certain number of miner's inches of water from a particular stream without reference to the extent or location of the land which such water is intended to irrigate. To another party may be decreed a certain fraction of all the flow of a creek with or without reference to the area which such fractional part may irrigate. It is only where a definite number of miner's inches have been decreed to a stated number of acres that use has been made of the decisions in compiling the following tables:

Duty of water in court decisions in Montana.

Name of stream.	Date of decree.	Miner's inches of water.	Acres of land.
Carbon County:			
Sage Creek	Jan. 7, 1901	565	495
Cole Creek	Mar. 14, 1902	720	720
Red Lodge Creek	July 21, 1904	6,683	6,683
Rocky Fork Creek	Aug. 21, 1903	51,916	51,886
Blue Water Creek	Feb. 29, 1904	2,466	2,466
Total		62,350	62,250
Ravalli County:			
Eight Mile Creek	May 27, 1897	930	1,353
Lost Horse Creek	June 14, 1898	39	160
Barnaby Creek	Oct. 17, 1898	302	480
Larry Creek	do	257	280
Mill Creek	Mar. 9, 1903	2,993	4,249
Fred Burr Creek	Mar. 10, 1904	3,069	5,713
Sleeping Child Creek	Mar. 3, 1904	640	620
Total		8,230	12,855
Gallatin County—East Gallatin River	Apr. 2, 1892	2,614	2,623
Missoula County:			
Carlton Creek	Feb. 21, 1902	1,957	3,477
Rattlesnake Creek	July 9, 1903	1,803	3,869
Total		3,760	7,346
Sweet Grass County:			
Bridger Creek	Mar. 18, 1898	455	880
Spring Creek	Nov. 17, 1899	300	320
Big Boulder River	Feb. 16, 1901	400	320
Do	Feb. 19, 1901	700	625
Duck Creek	do	450	1,400
Otter Creek	June 25, 1903	675	1,410
Duck Creek	do	2,386	6,032
Total		5,366	11,017

These summaries show that 82,320 miner's inches of water have been decreed to irrigate 96,091 acres of land, or at the rate of 1 miner's inch to 1.17 acres. In Carbon County during the past three years 62,350 miner's inches have been granted for the purpose of irrigating 62,250 acres, or slightly more than 1 miner's inch per acre, or 1 cubic foot per second for each 40-acre tract. This would require a continuous flow for about eighty-two days to supply a depth of 4.1 feet, the average of all the measurements reported in the preceding pages. The court decrees, therefore, correspond approximately to general practice.

SEEPAGE AND RETURN WATERS.

Unfortunately, most canals lose in transit large quantities of water, varying from 10 to 60 per cent of the amount diverted. A part of these losses frequently returns to the same stream either on the surface or through subsurface strata, and is diverted by other canals located at lower levels.

In irrigated valleys the first, second, and third benches, which extend upward like terraces from a stream, are usually watered by one or more canals on each bench. In other instances the irrigated lands occupy a plane which rises with a uniform grade from the bank of the stream. In both cases the canal, which is located next to the highest in a series, receives a large part of the water which percolates from the one above it and in turn transfers a part of its flow to the next lower.

The water supply of irrigated districts is still further influenced by seepage water from irrigated areas. Only a part of the water which is spread over the soil is utilized by the plants. The balance is either evaporated from the surface or percolates slowly through the subsoil. When porous bench lands are heavily irrigated a portion of what sinks beneath the surface returns to the river channels and augments to a considerable extent the available flow.

A knowledge of the quantities of water lost from canals and draining from irrigated lands and collected by other canals, or returning to the stream to be rediverted, is of great importance to courts in the adjudication of rights, and to administrative officials in the distribution of water from streams.

Seepage waters have likewise to be considered in providing for drainage. It would be wrong to conclude that the seepage losses from canals always return to the channel of the stream or were intercepted by other canals. Waste water of this kind quite frequently gravitates to the lower levels of an irrigated district and makes unproductive marshes and alkali flats of what otherwise might have been fertile fields. It is important to determine the extent of this loss in order to plan the size, number, and direction of the drains, and to endeavor to intercept the waste water before it reaches the lower levels.

Seepage from earthen canals represents the greatest loss of irrigation water, and until the amount is approximately ascertained for each canal it is not probable that any steps will be taken to lessen this loss.

LOSSES IN CONVEYANCE OF WATER.

The principal losses which occur in conveying water from a stream or other source of supply to the place of use may be grouped under one or the other of three heads. These are leakage, evaporation, and percolation.

LEAKAGE.

The loss due to leakage is readily traceable to faulty construction and can be remedied only by better structures and the exercise of higher skill in the building of canals. The wooden flumes to be found on nearly every canal are the chief source of leakage. Some leak so badly as to endanger their safety. This can be remedied by using a better grade of lumber and building the flumes in such a way as to insure water tightness. In many cases the best course to take with an old wooden flume is to substitute for it something more permanent. This has been done by the officers of the Big ditch in Yellowstone County. When this canal was first built many wooden flumes were used to cross depressions. In time these structures decayed, but instead of having them replaced the superintendent built earthen embankments on each side. These carried water more efficiently and were permanent structures, thus lessening the annual cost of maintenance.

Leaks are sometimes caused by the shattering of rock or other material by blasting during construction, or by failing to provide impervious connections between canal embankments and the original surface. Another source of loss is leaky gates. A slight leakage from the closed head gate of a farmer's lateral is a trivial matter, but the combined loss from a score or more of badly fitting gates may amount to a considerable volume of water.

LOSS OF WATER BY EVAPORATION.

The principal loss of water by evaporation occurs after the water is spread over a field and not while it is being conducted in canals. During the early part of the irrigation season in Montana the temperature of water in canals is quite low, often between 50° and 60° F., and the evaporation in consequence is low.

The basis for computing the loss of water by evaporation from ditches and canals has been the evaporation from a standard tank at Bozeman. The records for the irrigation season extending from May 1 to September 30 of each year, from 1900 to 1903, are given in the following table:

Evaporation from water surface at Bozeman, Mont. (in inches).

	May.	June.	July.	August.	September.	Mean.
1900.						
Mean temperature of water	....	73° F.	....	....	55° F.	64° F.
Monthly evaporation	5.52	5.99	3.59	3.88	2.74	4.34
Average weekly evaporation	1.24	1.39	0.80	0.88	0.63	0.99
1901.						
Mean temperature of water	59° F.	60° F.	68° F.	69° F.	56° F.	62° F.
Monthly evaporation	5.27	4.20	4.34	5.27	3.43	4.30
Average weekly evaporation	1.19	0.98	0.98	1.19	0.80	1.03
1902.						
Mean temperature of water	54° F.	67° F.	65° F.	65° F.	54° F.	61° F.
Monthly evaporation	3.40	3.30	4.07	3.60	3.01	3.49
Average weekly evaporation	0.77	0.77	0.92	0.81	0.70	0.79
1903.						
Mean temperature of water	61° F.	62° F.	64° F.	67.6° F.	68° F.	64.5° F.
Monthly evaporation	[a]1.12	3.99	3.90	3.38	3.36	....
Average weekly evaporation	0.60	0.93	0.88	0.76	0.78	0.79

[a] May 19–31.

Taking the results as given in the preceding table, the average weekly evaporation from May 1 to September 30, of a four-year period, amounts to a trifle more than 0.9 inch per week. This figure has been taken to compute the loss of water by evaporation from typical canals. The following table gives the results of such computations for ten canals:

Amount of water evaporated from typical canals in Montana.

Number of canal.	Discharge.		Width of surface.	Evaporated per mile of canal.
	Cu. ft. per second.	*Miner's inches.*	*Feet.*	*Miner's inches.*
1	6	240	5	0.13
2	12	480	6	.15
3	25	1,000	9	.23
4	40	1,600	12	.31
5	70	2,800	20	.52
6	110	4,400	25	.65
7	200	8,000	31	.81
8	300	12,000	40	1.04
9	400	16,000	47	1.22
10	600	24,000	58	1.51

It has been considered desirable to give a reasonably close estimate of the loss by evaporation from typical canals in order to correct a false idea which is prevalent regarding it. It is not unusual for irrigators to hold that the greater part of the losses which occur between the intake and their fields is due to evaporation instead of to seepage. Now, the computations show that this loss, even in large canals, is not worth reckoning with. A canal, for example, 12 feet wide on top and carrying 1,600 miner's inches, loses less than a third of a miner's inch per mile, while one 40 feet wide and carrying 12,000 miner's inches loses a trifle more than 1 miner's inch.

SEEPAGE.

In the measurements that have been made to determine the losses in the transportation of water for irrigation purposes few attempts have been made to separate the volumes lost in different ways. It has been previously shown that the amount evaporated is small in comparison with the total loss. In canals that are skillfully maintained and operated the loss due to leaks is likewise small. It is apparent, therefore, that by far the greatest loss arises from percolation or seepage. The results given in the table which follows include loss from all sources, the greater part of which is, as just stated, from seepage. The canals tested were usually representative of the larger class in the district. After one had been selected the necessary arrangements were made with the superintendent before the date fixed for the beginning of the test. A gauge rod of some kind was inserted near the intake, and the discharge ascertained by means of a current meter. The person in charge of the head gates was then instructed to hold the water at the same height during the subsequent measurements. The field party then traveled down the canal, measuring each diversion and each inflow as they passed it. At some suitable point on the canal, preferably at a road crossing, the canal was measured a second time. The difference between these measurements, provided there were neither diversions nor inflows, represented the losses in transit between the points of measurement. In case there were diversions through laterals and inflows from creeks or other sources the canal was debited or credited, as the case might be, with the respective amounts. All measurements of main canals were made with current meters in the customary way, but the methods used in the measurement of laterals depended somewhat on the accuracy of the measuring devices belonging to each canal. As a rule all lateral diversions were measured over weirs or with current meters.

The results of all such measurements made are summarized in the following table:

Losses from canals by seepage and evaporation.

Name.	Date.	Length measured.	Flow at upper end.	Loss.	
				Cubic feet per second.	Per cent.
		Miles.	*Cu. ft. per second.*		
Yellowstone Valley:					
Big ditch	August 9-13, 1900	22.00	251.47	65.05	25.56
Do	June 10-13, 1902	33.90	310.77	47.11	15.16
Do	August 4-6, 1902	30.40	300.65	29.07	9.25
Do	1903	28.86	382.92	12.20	3.19
High Line canal	do	18.51	75.20	20.34	19.29
Yellowstone ditch	do	7.00	35.60	6.89	19.35
Italian ditch	do	9.62	50.60	−2.70	−5.04
Canyon Creek ditch	do	12.00	59.72	10.76	18.02
Mill ditch	do	8.00	29.33	1.78	6.07
Flaherty Flat ditch	do	3.00	21.28	1.17	5.25
Merrill ditch	do	8.25	30.81	5.26	17.07
Gallatin Valley:					
West Gallatin Irrigation Company	July 18-20, 1900	38.75	114.45	39.06	34.13
Do	June 24-25, 1902	26.50	93.67	26.31	26.66
Do	1903	23.25	70.08	18.80	26.82
Cameron ditch	do	7.82	26.48	7.60	28.17
Farmers' canal	1900	10.75	133.10	23.59	17.65
Kleinschmidt	1903	17.50	96.11	10.24	9.65
Bitter Root Valley:					
Republican canal	1900	11.60	120.49	35.35	29.34
Do	1902	12.00	65.52	18.16	27.71
Do	1903	5.25	88.11	6.83	7.75
Do	do	9.75	76.46	6.09	7.96
Hedge canal	1902	17.75	80.83	16.08	19.90
Do	1903	17.50	99.96	3.24	3.03
Ward ditch	1902	7.40	55.32	2.00	3.62
Do	1903	8.00	35.09	7.82	20.53
Skalkaho ditch	1902	5.96	37.92	5.07	13.39
Do	July, 1903	5.50	29.32	3.09	10.54
Do	August, 1903	5.50	32.58	1.18	3.62
Surprise ditch	1902	5.00	51.20	18.61	30.84
Supply canal	do	14.00	60.90	40.56	66.60
Allen, Hughes, et al	1903	1.25	8.32	1.80	21.63
Fowler and Sistah ditch	do	3.00	7.23	1.61	22.27
Union ditch	do	6.00	36.49	3.13	8.26
Average					18.22

It should be borne in mind that the loss shown in the above table is the net loss, as most canals receive more or less inflow from above. In one case this was so great that the canal showed a net gain. Again, the portions of the canals measured represent only a part of the total loss by seepage in the conveyance of water from the natural stream to the irrigated fields. No attempt was made to determine the losses in the network of laterals which take the water to the boundaries of the fields.

The effect produced on the flow of a canal by the inflow of seepage from another and higher canal, and the land which it irrigates, is well illustrated by the Big ditch. August 9–13, 1900, there was a total loss on this canal from Tilden's ranch to Hesper farm, a distance of 22 miles, of 65 cubic feet per second, or 25.56 per cent of the total flow. In the following year water was turned into a new branch of this same canal known as the High Line, and the seepage from this new branch and from the irrigated farms under it produced a noticeable change in the flow of the main canal. In June, 1902, there was sufficient inflow from the High Line canal to reduce the seepage losses in the main canal to 47.11 cubic feet per second in 33.9 miles, or a total net loss of only 15.16 per cent. In August of the same year a second series of measurements was made and the total loss was but 9.25 per cent in 30.4 miles. The results of measurements made on the same canal in the summer of 1903 show that a still larger quantity of seepage water was admitted from the upper canals which included not only the High Line, but also the Yellowstone canal.

The Yellowstone ditch and also the High Line canal are located at higher elevations than the Big ditch, and it is presumed that a part of the water which escaped from these channels was intercepted by the Big ditch. However, since the combined loss from the channels was 27.23 cubic feet per second this alone would not suffice to produce the change previously mentioned in the Big ditch. The balance must have come from irrigated farms.

The measurements of the Italian and Canyon Creek ditches of Yellowstone Valley show that there is a large flow into both ditches. This is readily accounted for by the fact that there are canals and irrigated areas above each.

There was a large increase in the Mill ditch in the third and fourth miles from the head, which would appear to indicate the admission of a tributary, but the increase was wholly due to seepage water.

The results of measurements made on the West Gallatin irrigation canal during 1900, 1902, and 1903 differ from those of the Big ditch in Yellowstone Valley in that the former show a somewhat fixed régime. This condition is readily accounted for. There are no canals located on higher ground, and consequently no irrigated areas from which waste water might drain into the canal. In 1900 the loss from the entire canal, including Camp Creek lateral, was about one-third of the volume admitted. The tests made in 1902 and 1903 were each made by different parties, and frequently different gauging stations were selected from those used in 1900. Notwithstanding this difference in many of the sections into which the canal was divided, the results obtained in the three years show that conditions have not been materially altered in a four-year period.

Middle Creek canal consists of a main canal something over 4 miles long, and two branches known as North and East forks. Four tests made from 1899 to 1902 show that under ordinary heads the seepage loss in the main canal averages about 20 per cent of the volume admitted. In the North Fork there is a gain—that is, the waste water which flows into it from adjacent irrigated farms more than counterbalances the losses due to percolation in the channel. This gain of 20 to 30 per cent in the North Fork reduces the loss over the entire system to about 16 per cent of the flow through the head gate.

In the Cameron or Kughen ditch the total loss, which does not appear to have been reduced by the inflow of seepage, is 28.7 per cent of the volume admitted. As has been stated in connection with other canals, this is not the actual loss by seepage from this canal, but rather the net loss, which is the actual loss diminished by the amount of inflow. The seepage inflow into the Kleinschmidt canal is derived from creek channels and narrow irrigated valleys.

In 1900, when the first seepage measurements were made on the Republican canal, there was a heavy loss in the upper portion of the canal. On July 21, 1900, out of a total of 120.49 cubic feet per second admitted through the head gate, 35.35 cubic feet per second was lost by percolation before the canal passed Grantsdale, 3.6 miles below the head. The loss in a distance of about 10 miles below this upper section was counterbalanced by seepage waters from irrigated areas above the Republican canal. The results for 1902 show that the net loss has been reduced by the interception and admission of percolating waters from the Hedge canal, immediately above the Republican. In 1903 only the upper portion of the canal was tested, but the results show a still further diminution in the net loss by seepage. In 1 mile there is a gain of 2.97 cubic feet per second, showing that sufficient percolating water from higher elevations was admitted not only to make up for the loss but to produce a surplus.

The results of seepage measurements made throughout the entire length of the Hedge canal in 1902 and also in 1903 show that conditions are changing. In 1902, 16.08 out of 80.83 cubic feet per second admitted was lost. If earlier measurements had been made they would probably have shown that this loss of 19.9 per cent was not the total loss, because in 1903 it is found that out of nearly 100 cubic feet per second admitted there is only a net loss of 3 per cent. In a distance of 2 miles there is a gain of 5.24 cubic feet per second, derived from the seepage waters of Skalkaho Creek, and in other sections there are large gains derived from waste waters from irrigated farms.

It is likewise evident from the figures given in the table that the Ward canal has no fixed régime. The net loss arising from seepage seems to depend on the amount of water which percolates from higher ground and which is intercepted by this canal.

There is less fluctuation in the net flow of the Skalkaho canal, due, doubtless, to the fact that in more than one-half of its length it flows through a flume which is practically water-tight.

THE EFFECT OF SEEPAGE AND RETURN WATERS IN AUGMENTING THE FLOW OF STREAMS.

During the summer of 1903 a series of measurements to determine the gain due to seepage was made on the Bitter Root River.

That part of the Bitter Root River which was included in the investigation extends from Grantsdale highway bridge to the Buckhouse bridge, a distance of 48 miles, and includes the bulk of the irrigated area of the Bitter Root Valley in a north-and-south direction. The arable and irrigable lands in an east-and-west direction average about 10 miles in width over this same length.

The first series of measurements was made from June 11 to 15, 1903, and consisted of a measurement of the river at Grantsdale and a measurement of each of 39 tributaries, as well as five diversions through irrigation canals. The results of the first series of measurements, expressed in cubic feet per second, are as follows:

Return seepage, Bitter Root River, June 11–15, 1903.

Discharge of river at Grantsdale, Mont	9,111.3	
Inflow from 39 tributaries	5,764.2	
Total inflow		14,875.5
Discharge from river at Buckhouse bridge	12,660.6	
Diversions through canals	313.5	
		12,974.1
Loss in 48 miles		1,901.4

The second series was made about a month later, between July 9 and 14, after the spring floods had subsided. The results of the second series of measurement, expressed in cubic feet per second, are as follows:

Return seepage, Bitter Root River, July 9–14, 1903.

Discharge of river at Grantsdale, Mont	2,320.9	
Inflow from tributaries	1,623.8	
Total inflow		3,944.7
Discharge of river at Buckhouse bridge	4,221.7	
Diversions through canals	161.7	
Total outflow		4,383.4
Gain in 48 miles		438.7

The third series was made from August 7 to 14, at a time when the discharge of the river and the various tributaries was quite low. The results of the third series of measurement, expressed as before, are as follows:

Return seepage, Bitter Root River, August 7–14, 1903.

Discharge of river at Grantsdale, Mont	325.5	
Inflow from tributaries	209.5	
Total inflow		535.0
Discharge of river at Buckhouse bridge	1,536.8	
Diversions through canals	111.8	
Total outflow		1,648.6
Gain in 48 miles		1,113.6

The foregoing figures show that a large volume is held back during the flood period, when all the natural channels are full, and that much of the water which is temporarily stored in this way returns to the channel of the river to augment the flow during the latter part of the season. According to the measurements, a volume of 1,901 cubic feet per second was retained on June 11–15. The only way to account for this loss is by infiltration in the soils and subsoils of the valley. It is probable this process went on over about 480 square miles of open, gravelly soil, and if this is so it is not surprising that a stream of nearly 4 cubic feet per second on an average should be absorbed by each section of land. Figure 18 shows that this process of absorption or infiltration of water, if one considers the entire area affected, terminated about July 6. After this date there is a gain instead of a loss. This gain is small at first, but at the end of thirty-seven days increases to 1,113 cubic feet per second. The conditions found between August 7 to 14 are remarkable. The total discharge of the stream at Grantsdale is only 325.5 and that of all the tributaries 209.5, or 535 cubic feet per second in all. At the same time there is an available flow of 1,648.6 cubic feet per second at a point 48 miles farther down the stream. In other words, the increase is more than double the ordinary flow of the stream.

It is not to be inferred that this increase was derived wholly from return waters which were for a time absorbed in the subsoil of 480 square miles of porous lands. A large part was undoubtedly due to seepage losses from the irrigated farms in the same valley.

That the conditions which obtained on Bitter Root River in 1903 are not unusual is evidenced by similar conditions which have been shown to exist on other western streams.[a]

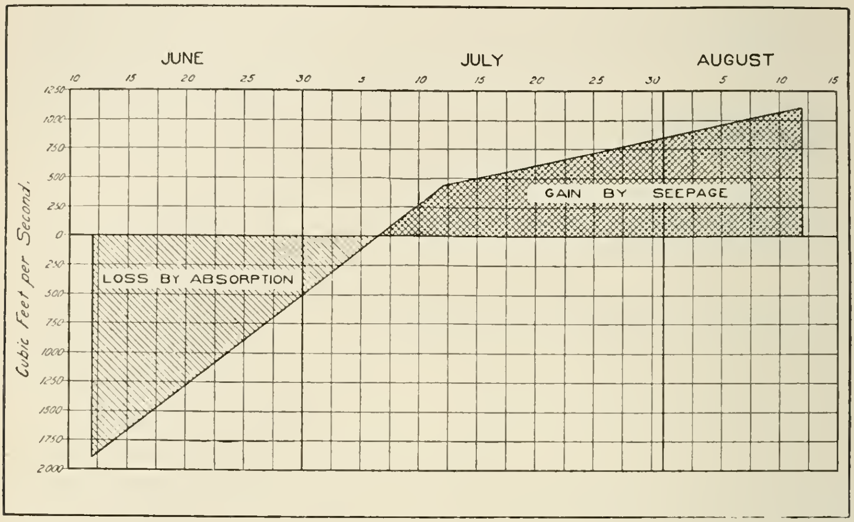

FIG. 18.—Loss by absorption and gain by seepage in 48 miles of Bitter Root River, from June 12 to August 12, 1903.

CONCLUSIONS AND RECOMMENDATIONS.

WASTE OF WATER.

According to the author's estimate, the total area that is ever likely to be irrigated in Montana from streams, reservoirs, and wells will not exceed 6,000,000 acres, while the fertile and arable land that might be irrigated may comprise three times this area. The reason for this low estimate is the smallness of the water supply, the short period of plant growth, and the fact that the large tracts of irrigable land are not always accessible to the large streams. This estimate was based on an average supply of 2 acre-feet of water for each acre of land, which may be regarded as the minimum quantity required under the most economical use which is to be expected.

The average quantity diverted per acre irrigated, as shown by the measurements reported in the preceding pages, is 4.1 acre-feet, or more than twice the quantity used in the estimate (see p. 12). In so far as rights have been adjudicated, the courts have confirmed rights to this quantity (see p. 89).

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[a] See U. S. Dept. Agr., Office of Experiment Stations Bul. 158.

The difference between these quantities represents the possible extension of the irrigated area in Montana, after the streams are exhausted under present practice. The measurements of return seepage (see p. 96) show that at least a part of this water drains back to the streams, to be used again, but undoubtedly a large part of this excess is lost by evaporation when spread over the ground, and by percolation into substrata which does not drain back into the surface streams. Further, the water thus wasted is likely to injure either the land to which it is applied or that lying below. This necessitates drainage to protect land against water-logging and alkali. The two great sources of loss are poorly constructed ditches and careless irrigation.

POORLY CONSTRUCTED DITCHES.

Middle Creek canal, in Gallatin County, may serve as an illustration of the waste of water in ditches. It was begun in 1871 by a small association of farmers who had neither sufficient means nor the necessary equipment to build a good canal. The ditch was located with a spirit level fastened to a tripod. Each stockholder was required to provide a certain number of men and ox teams and to perform an amount of labor proportionate to the number of shares of stock which he owned. Thus this badly located canal was built at odd times in a sort of haphazard way. Questions of grade, of suitable materials, or of loss by percolation did not worry these farmers; their main object was to get water to their ranches, and if a few plow furrows served their purpose they were content.

Under the conditions which then existed the members of this pioneer cooperative association may have pursued the proper course. Water was then cheap and fairly plentiful, the new settlers were poor, and it might have been unwise to spend more money on the canal at that time. But thirty-three years have changed conditions around Middle Creek. Many of the first settlers who began without means have since become well to do; comfortable farm dwellings have taken the place of log cabins, land has quadrupled in value, and water is both valuable and difficult to obtain. Of former landmarks, the old ditch has changed least. Few improvements have been made, the water still ripples over the cobbles in the bed, the head gates are taxed to resist the spring floods, the farmers' head gates are crumbling to pieces, and the distributing ditch is cutting each season a deeper gully in the cultivated field. But worst of all, during thirty-three years, nothing has been done to lessen the waste of water by percolation. For every 5 cubic feet of water taken out of the creek 1 is wasted before this volume has flowed 4 miles.

Some canals show even larger losses. The measurements made show losses of over 30 per cent in a single mile, while the average loss for all canal measurements reported is 18.22 per cent (see p. 93). While it is impossible to prevent all these losses, great improvements can be made at small expense.

As the demand for water increases these conditions will tend to be corrected, but the practice of the courts of decreeing rights to enough water to supply land after a large part of it has been lost in transit will not tend to correct this evil. If a man is granted sufficient water for his land under economical use, and this quantity is measured to him at the head of his ditch, he will make every effort to stop losses which leave him without water enough for his land. This has been done in Nebraska. The law fixes the limit at 1 cubic foot of water per second for 70 acres, and the State supreme court has held that the measurement must be made at the head of the ditch. The State certainly has a right to insist in this way upon an economical use of its resources.

CARELESS IRRIGATION.

Where irrigated farms are large and skilled labor difficult to secure, the tendency is to crop a larger area than can be properly cared for. The average Montana farmer likes to have a large acreage in crops. His fields, as a rule, are well plowed and harrowed, but having performed what he considers these necessary preliminary operations and drilled in sufficient seed, he pays little attention to the condition of the surface for rapid and efficient irrigation. More care in this regard would pay well. If the surface is once carefully graded and the ditches located and built in such a manner as to meet the local requirements, a forage crop like alfalfa, may be grown for ten successive years with little additional outlay. The same is practically true of a grain crop. Even with a hoed crop like potatoes or sugar beets, it is an easy task to reduce the surface to a uniform grade before the next crop is seeded.

The surface of the average irrigated land can be put in reasonably good condition for irrigation for $5 per acre, but to be safe it is here assumed that the cost is $7.50. This principal at 12 per cent would yield a revenue of 90 cents a year, and represents the difference between a rough, uneven surface and a smooth, graded surface. In the case of alfalfa, which is cut three times, this annual interest would amount to 30 cents per acre for each crop. The labor of irrigating the properly prepared field is much less, there is a saving of water, the soil is not damaged, there is considerable increase in the yield, and the quality of the crop is improved. Taking all this into consideration, an expenditure of $7.50 per acre would return 60 instead of 12 per cent. While only one crop is harvested in a year, the advantages of a carefully graded field would need to be worth 90 cents per acre a year, but there are few practical irrigators who would not admit that the extra quality of the yield, apart from any other consideration, would more than compensate for this outlay.

The saving of water would also be of great advantage to the State, since it would make possible the irrigation of more land. As was suggested in the discussion of poorly constructed ditches, rights should be limited to enough water for the land irrigated under good practice. Then the loss from waste of any kind would fall on the one making the waste.

RIGHTS TO THE USE OF WATER SHOULD BE DEFINED AND ESTABLISHED.

Of the 1,500,000 acres irrigated in Montana only a small percentage has a well-defined and clearly established water right. In all probability the adjudicated rights to the use of water do not cover more than one-tenth of the total irrigated area.

The records pertaining to the appropriation of water, as filed in the recorder's offices of the respective counties, possesses little value, for the reason that the majority of claims filed do not represent accurately the plans of the claimants and there is no means of ascertaining from the records themselves which plans have been perfected and which have been abandoned.

No definite or accurate information can be obtained from county or State records regarding the volumes which are either appropriated or unappropriated from any public stream within the boundaries of the State. Neither can any accurate information be obtained from county or State records regarding the volumes carried by irrigating ditches or the extent of the land which each ditch waters.

Those who have maintained or who have been compelled to defend a suit in court until they secured a decree are seldom protected in their rights. Again, some decisions of the courts in water cases are entirely ignored by those who distribute and use the water to which the decrees refer, and there is no means of finding out from the records which decrees are to be observed and which may be disregarded. The small percentage of rights which have been determined have not proved satisfactory on account of the time required, the excessive cost to the litigants, and the spirit of controversy, if not of open hostility, which usually exists between opposing claimants, thus precluding the possibility of ascertaining the facts. Besides, many decisions are considered so faulty as to be entirely ignored by the owners of the rights affected.

With few rights determined, and with little provision for the equitable distribution of water according to priorities, it is not surprising that waste, illegal diversions, and unjust allotments should prevail.

Unjust distribution of water and failure to obtain it at the right time greatly affect the annual yields. Again, there is the time and labor lost in striving to protect one's rights: one man irrigates while another patrols the ditch. This common property, so valuable to the farmer, is not controlled by either the State or the nation, and men quarrel over it well-nigh continuously throughout the season. The division of water is the chief topic discussed in farm homes from seed time to harvest, and communities seem willing to spend the greater part of their earnings in protracted litigation. If some of the disadvantages which the owners of irrigated farms have to contend with were removed it could not but result in great gain to the revenue of the State. Take, for example, the one item of increased yield resulting from equitable division and continuous use of water, and few would estimate the value of this increased yield at less than 25 cents per acre. This is seemingly a trivial sum, yet in the aggregate it would amount to $375,000 a year.

As has been stated, the waste of water, which is the greatest evil in Montana irrigation practice, will tend to correct itself as the demand for water increases, but the evils arising from undefined rights and the lack of public supervision of distribution will grow with the demand for water and greatly limit future development. These are matters which can be corrected only by proper legislation.

In the opinion of the writer, some of the essential features of the irrigation legislation needed by the State of Montana are as follows:

(1) To declare the principles herein named upon which the right to use water shall be based:

(*a*) That the waters of the State shall be subject to appropriation for beneficial use: *Provided*, That no water can be legally diverted which is not put to a beneficial use.

(*b*) That rights to water for irrigation shall be appurtenant to definite tracts of land, specified in the applications and permits on which the rights are based, except that rights can be transferred to other tracts, or used for other purposes, where such transfer or change in use does not injure holders of other rights or reduce the supply beyond the amount of the water transferred or used for other purposes: *And provided further*, That no transfer or change of use shall be made until approved by the State engineer or the court, after a properly advertised hearing has been given to all interested parties.

(2) To make adequate provision for an early and equitable adjudication of rights to water which have already accrued, thus providing a guide for the distribution of water and for determining the amount of the unappropriated waters.

(3) To provide for the acquirement of rights in the future by application to the State engineer, and the construction of works and use of water after the issuing of a permit by the engineer; the right to be

confirmed by the State after satisfactory proof to the engineer that the conditions of the permit have been fulfilled and the water applied to beneficial use.

(4) To keep a complete record in the office of the State engineer of each perfected right to the use of water, of each application, and of each permit for a new diversion or use.

(5) To divide the State, according to drainage basins, into divisions and districts for administrative purposes.

(6) To provide an administrative system for the equitable distribution of water among those entitled to its use.

TRANSFERS OF WATER RIGHTS.

In recommending that rights to water for irrigation be made appurtenant to the land watered it is not intended to make this provision too rigid. When a tract of land becomes too moist to need water, or when it becomes unprofitable to apply water, it is to the interest of both the owner and the public that he be accorded the privilege of transferring the water right to a more productive tract of land. But in granting this privilege there are two classes of rights that should be guarded, viz, those of neighboring water users and those of the public.

In order that these interests may be protected, provision should be made for determining in advance of the transfer whether the rights of others or the public will be injured. The Montana law at present provides that transfers may not be made when the rights of others are injured; but the usual practice is for the transfer to be made, after which anyone claiming to be injured may bring suit to have it stopped. This puts on the one who certainly derives no benefit, and who may be injured, the burden of preventing the transfer. In Idaho the party wishing to make the transfer must make application to the State engineer, who holds a hearing after advertisement of the application and the time and place of the hearing. This places the burden where it belongs—on the party who is to benefit by the transfer. Such a hearing will also enable the State engineer to determine whether the transfer will be detrimental to the public interest.

ADJUDICATION OF EXISTING RIGHTS.

The rights to water which have been acquired should be defined and established. Without this any administrative system is useless, as those charged with distributing water will have nothing to go by, and the State engineer will have no means of knowing whether or not there is surplus water, rights to which may be acquired by applicants. On very few streams have the rights been defined and under the present system, as a rule, rights will not be defined until there is a shortage, and if they should be, rights acquired after an adjudication has taken place will not be included, which will make necessary new adjudications from time to time. If all existing rights are defined and new ones are acquired only under the supervision of the State engineer, this necessity for periodical adjudication will be done away with. For securing a complete list of existing rights the present law has two serious defects. Adjudications will take place only on the initiative of the holders of rights, and if they are indisposed to take the matter up, rights may remain undefined for years. This has been the experience in Idaho, where a law was passed which authorized the State authorities to begin such actions. The enforcement of this law was fought by the farmers who did not want to stand the expense of adjudication, and the law was declared void by the State courts (Bear Lake Co. *v.* Budge, 75 Pac., 615). But some way of forcing adjudication is absolutely essential to any orderly public control. Wyoming, Nebraska, Utah, and Nevada have such systems. Those in Utah and Nevada have not been tested in the courts, but the Wyoming and Nebraska laws have been repeatedly upheld by their State courts. Under these laws, State officials make surveys and measurements of the ditches and irrigated lands, and take testimony as to dates of construction and other facts bearing on the dates of acquirement and volume of rights, and on the basis of the surveys and the testimony define the rights. Appeal from such decision to the courts is provided for, but is not generally taken. The second serious defect with the present Montana system is that no provision is made for surveys to secure the facts as to capacities of ditches and areas irrigated. Decisions as to rights which depend entirely on these facts, so far as their volume is concerned, are based entirely on interested testimony. Whether rights are defined by administration officials or by the courts this exact knowledge as to physical facts is essential to just conclusions. In Utah, Idaho, and Oregon rights are defined by the courts, but the law provides for surveys by the State engineer as a part of every adjudication. In Wyoming, Nebraska, and Nevada rights are defined by administrative officers as the basis of such surveys.

This work involves the use of substantial head gates to control diversions and suitable measuring devices to determine the flow. These structures should be inserted by and at the expense of the respective owners under the supervision of the State engineer. As these structures will cost a considerable sum the cost of making the hydrographic survey and the necessary maps and compilations should be paid by the State. The general benefit from this work is surely sufficient to justify the State in bearing this expense.

The system of State control of irrigation recommended is based upon the police power of the State. In several States the unappropriated waters are declared to be the property of the State as a basis for laws controlling the acquirement of rights and the distribution of water, but in Wyoming, the only State having a constitutional declaration that the water belongs to the State, the supreme court has held that "The public ownership * * * is rather that of sovereign than proprietor," thus basing the laws of that State on its police power rather than on its proprietorship of the water (Willey *v.* Decker, 73 Pac., 210). The Colorado constitution declares that the unappropriated waters of that State are the property of the public, and its court has repeatedly upheld its irrigation laws as a proper exercise of its police power. The constitution of Montana declares that the beneficial use of water is a public use, and any further declaration on this subject is not deemed necessary.

The additional data required for proper adjudication of rights consist of reliable testimony pertaining to the dates of appropriation of existing rights and accurate information regarding the early use of water from each ditch and the subsequent enlargement, if any. The codes of Western States differ as to the methods of procedure of obtaining these additional facts and of making the final determination of water rights. In Utah the district court appoints from one to three referees; in North Dakota the attorney-general, aided by the district attorneys of the districts affected, bring suit, while in Wyoming the adjudications are made by a board of five State officers, the majority of whom are thoroughly familiar with the character of the stream under consideration, the nature of the diversions, the character of the land irrigated, and the kind of crops grown. The vital point involved is that the settlement of these questions shall be placed in the hands of men having an expert knowledge of canal management and the practical requrements of irrigated agriculture. A duty of such far-reaching importance should not be imposed on either the attorney-general or the judges of district courts for the reason that they may be too much burdened with other duties to give the necessary time and thought to such water suits.

DUTY OF WATER.

In Montana at least one-fourth of the total available stream flow in summer is now diverted and applied to land. In defining the rights which have been acquired no fixed general duty can be legally established, since each water-right owner is entitled to the amount of water which he has been accustomed to apply in an economical way. The duty of water for such rights must therefore be based on beneficial use and may vary with the length of the irrigation season, the character of the soil, nature of the crops, etc.

In the case of rights to be acqured the State has a free hand, and it may place a maximum limit on the amount of water which may be diverted to irrigate a given area of land. In the opinion of the writer this maximum amount should not exceed 3 acre-feet. Fifteen inches of natural rainfall and 36 inches of irrigation water, or 51 inches in all, should be ample for any crop.

In all rights that are hereafter to be acquired the maximum time of use as well as the maximum quantity should be specified. This time limit for summer irrigation might be fixed at five consecutive months. A provision of this kind is necessary in order to utilize to the fullest extent the available water supply. Water is now used in Beaverhead and other counties for winter irrigation. As the area devoted to dry farming is increased the use of water during the early spring and fall months, and even in winter, is destined, it is believed, to increase in a more rapid ratio. It would seem to be well, therefore, to clearly define all kinds of rights to the use of water. One man desires water only during the crop-growing season, which is assumed to be five months; another desires water for winter irrigation, which may be assumed to be for a definite period also; while a third desires to divert a part of the flood flow to fill his storage reservoirs. Now, it would seem to be the duty of the State to permit all of these appropriations and others that may arise, but to so define both the time and amount that conflicts may be avoided.

ACQUIREMENT OF RIGHTS.

The adjudication of all existing rights will fall far short of its greatest value if it is not accompanied by a provision that in the future rights can be acquired only under such supervision as will insure a public record of their dates and volumes, in order that there may be at all times a complete record of rights. The systems adopted for this in Wyoming, Nebraska, Idaho, Utah, and Nevada are in general the same, and may be considered the best. The person wishing to acquire a water right is required to apply to the State engineer, stating in prescribed form how much water he wants and from what source, the location of his irrigation works, and the lands to be irrigated. If this application is in proper form, and there is unappropriated water in the source of supply, a permit is issued fixing the conditions under which the work must be done and the time when it must be completed. On or before the expiration of this time proof of completion must be submitted, and a certificate is then issued stating what rights have been acquired. Such a system is not intended as a limitation on the acquirement of rights, but rather as a means of encouraging construction by relieving the builders of works of uncertainty as to the water supply and of the necessity of fighting for their rights in the courts.

ADMINISTRATIVE SYSTEM.

The need of competent State officers to divide the flow of canals and streams in a just manner among the water users has been keenly felt in Montana for more than a decade. In 1889 the State legislature, in order to relieve the situation to some extent, enacted the following:

[House bill No. 106. Approved March 2, 1899.]

Sec. 1. Whenever the water rights pertaining to any stream or water system within the State of Montana have been determined by a decree of a competent court it shall be the duty of the district judge of the district within which such water rights are situated, upon the application of the owners of at least twenty-five per cent of the water rights affected by such decree, to appoint a commissioner, who shall have the authority to measure and distribute to the parties interested under such decree the water to which they are entitled according to their priority, as established by such decree; and for that purpose such commissioner shall have authority to enter upon any ditch, canal, aqueduct, or other source of conveying the waters affected by such decree, and to visit, inspect, and adjust all head gates or other means of distributing such waters, and shall have the same power as a sheriff or constable to arrest any and all persons interfering with the distribution made by him and to take such persons before the judge of the district court for trial for contempt of the decree of said court.

Sec. 2. The parties using the water shall be liable for the payment of the fees and compensation of such commissioner, and the judge of the district court is authorized and directed to fix the compensation of such commissioner and to apportion the amount of such compensation proportionately among the water users named in said decree, and which said order shall have the force and effect of a judgment and may be enforced by an execution.

Sec. 3. If said commissioner shall fail to perform the duties imposed upon him by order of court he shall be deemed guilty of contempt of the order of said court.

This law has been a benefit to a small number of irrigators. Those whose rights had been established by a decree of the court took advantage of the means provided, petitioned the court to appoint a water commissioner, and had their water supply properly apportioned. As a rule, the commissioners were young men who were completing a course in engineering at the agricultural college of Montana, and being familiar with modern methods of measuring water, as well as honest and capable, their work was satisfactory. The sphere of action of the law is extremely limited because few rights have been established.

The act was amended by the last legislature, granting permission to commissioners to maintain ditches at the expense of the owners, provided that the majority of the water users desire it. Provision is also made for a hearing before the judge of any district court when a water user is dissatisfied with the distribution of water as made by the water commissioners. The water commissioner is likewise required to submit a full report to the judge at the close of the former's term of service, showing in detail the total amount of water distributed to each water user during the season and the total cost for repairs and maintenance, whereupon the judge fixes the sum which each shall pay in proportion to the amount of water which each has received. Any person who is dissatisfied with the report of the water commissioner may have a hearing before the judge.

The amended law requires the water user to provide a suitable head gate and a measuring device, and persons failing to supply these structures receive no water.

With general provision for the adjudication of all existing rights and the orderly acquirement of rights in the future, it would seem best to supersede the present commissioners appointed by the courts by those appointed by the governor under some system that will insure the appointment of men familiar with irrigation practice.

In providing for distributing water each drainage basin should be regarded as a unit. The wisdom of this course is plainly seen in the behavior of the Bitter Root River. On August 12, 1903, the flow at Grantsville was 327 cubic feet per second, and leaving out of consideration the inflow from tributaries, the gain due to seepage in a distance of 48 miles was 1,111 cubic feet per second. It would, therefore, be unnecessary to shut water out of late canals at the upper end to supply older ones below, since they would be supplied by seepage. A long stream would not be within the jurisdiction of a single court, and some official with a wider jurisdiction than a court commissioner should have charge of the distribution of water from such a stream. In Colorado, Wyoming, Nebraska, Utah, Idaho, and Nevada this has been provided for by the appointment of water commissioners by the governor, upon recommendation of the county commissioners in some States and of the division engineer or superintendent in other States. In each of these States the plan is to divide the State into divisions on drainage lines in such a way that no stream will be in more than one division, and divide these into districts of any convenient size, trying to arrange them so that they will be as nearly independent as possible. For each district there is a commissioner who has direct charge of the distribution of water within his district, and for each division there is a superintendent who has general supervision of the work of the commissioners and decides all questions between districts where a stream and its tributaries extend into more than one district.

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Issued January 4, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN 173.

A. C. TRUE, Director.

CORN-HARVESTING MACHINERY.

BY

C. J. ZINTHEO,
EXPERT IN FARM MECHANICS.

1862 1889

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

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Issued January 4, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN 173.

A. C. TRUE, Director.

CORN-HARVESTING MACHINERY.

LIBRARY
NEW YORK
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BY

C. J. ZINTHEO,
EXPERT IN FARM MECHANICS.

1862 1889

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., September 25, 1906.

SIR: I have the honor to transmit herewith a report on Corn-harvesting Machinery, by C. J. Zintheo, of this Office. This report briefly sketches the history of corn-harvesting machinery in this country, describing in more or less detail the various implements and machines which have been used and are now in use, and discusses the economy of using such labor-saving devices.

On a large part of the corn land of this country the grain only is harvested, leaving the stalks in the field to be consumed by cattle to some extent, but principally to go to waste, and remain in the way of subsequent cultivation. In this way a large part of the food value of the corn plant is lost. The great object of the introduction of corn-harvesting machinery is to prevent this loss.

The report gives figures as to the value of corn fodder, and the cost of gathering it with the various machines described.

Such a report should be of value to the farmers in the corn-growing sections, and its publication as a bulletin of this Office is recommended.

Respectfully,

A. C. TRUE, *Director.*

HON. JAMES WILSON,
Secretary of Agriculture.

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CORN-HARVESTING MACHINERY.

INTRODUCTION.

Corn was the earliest as it is the most important cultivated crop on the American farm. When the first colonists settled on American soil they found the Indians producing corn, and also preparing various foods from it. The first corn grown by white men was that of the Virginia Colony, at Jamestown, in 1608, and it is claimed that two Indians taught them how to plant and cultivate the crop. The product of this harvest served almost as the sole food supply of the colony. The early Massachusetts colonists, too, received their first lessons in corn cultivation from the Indians. The first fields cultivated by the settlers there were those which had been left vacant by the Indians.

The United States census of 1840 gives the corn yield for that year as 377,518,875 bushels. The following census (1850) places the yield at 592,000,000 bushels, with a corn acreage of 31,000,000. During the civil war little advance was made in the production of corn. In the year 1900 the United States alone produced 2,105,102,516 bushels, or about 75 per cent of the total crop of the world. In 1904 the yield of corn reached 2,467,480,934 bushels, and the acreage 92,231,581.[a]

It is only when compared with the production of other cereals that the importance of this crop is fully appreciated. At the present time one-fifth of the area in improved land in the United States, one-third the area in crops of all kinds except pasture, and one-half the area in cereal crops is devoted to corn. In 1899, while 35 per cent of the farmers of the United States raised wheat, 82 per cent raised corn. The total combined yield of wheat, oats, barley, rye, and buckwheat in the United States amounted in 1904 to 1,673,995,336 bushels, and the acreage was 79,649,720—these figures equaling two-thirds of the yield and four-fifths of the acreage of the corn crop. The farm value of the corn crop for 1904 was $1,087,461,440, while the combined value of the other crops mentioned for the same year was $877,120,785 or only 80 per cent of the value of the corn crop.[b] In 1905 the yield of the corn crop was 2,708,000,000 bushels and the value $1,116,700,000.

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[a] U. S. Dept. Agr. Yearbook 1904, p. 628.

[b] Ibid., p. 629.

There may be, moreover, a double harvest from every field of corn—that of the grain and that of the fodder. There are thousands of farmers in the United States who in the last few years have doubled the profit they used to make on their corn crop, by harvesting the whole plant—stalks, leaves, and all—yet there are tens of thousands of other farmers who still "snap" or husk their corn in the field, letting the stalks and blades go largely to waste. It has been demonstrated beyond a doubt that when properly harvested corn fodder is as nutritious as good hay. The farmer who would receive the full value of his crop should secure this fodder with as much care as he gives his hay, taking care that it is harvested at the proper period, and not allowed to have the nutrients it contains leached out by rains or injured by frost.

The composition of the dry matter of the fodder corn varies greatly with the season. The yield of food material increases with the advancing age of the corn, the largest amount being obtained when the corn is well ripened. Feeding experiments have been conducted with corn fodder by which it has been determined that at least 45 per cent of the food value of the corn plant is in the stalk, and that the stalk can be cut at the time the ear is dented without material loss to the kernel. A mine of wealth is thus opened to those farmers who are in position to make use of this fodder.

For years we have had machines which successfully harvest, thrash, and clean the small grains, so that every part of the plants may serve some useful purpose. The machinery for the care of the corn crop has been much more difficult to develop than any other line of farm implements. Altho there has been considerable progress in the harvesting of corn, no such profound changes have been made as those in the harvesting of small grain. The larger part of the crop is still husked by hand from the standing plant, and the crop is but partially utilized. In large sections of the country only the ears are gathered, while the leaves and stalks are almost a total loss.

After the success of mowing and reaping machines, inventors tried to develop a corn harvester along the lines followed in the construction of those machines. The old methods of harvesting corn fodder were slow, expensive, and laborious, and the manufacturers have long sought to solve the problem. Their success is not as yet complete, but the labor-saving devices so far perfected have largely changed conditions. The corn may now be cut, husked, and shredded with less labor than the cutting alone formerly required.

SIMPLE METHODS OF HARVESTING CORN.

TOPPING.

As a stock food, both the ears and the stalk of the corn plant have been used from the earliest times. The Aztecs and the Peruvian Indian tribes practised topping corn for this purpose at the time they were conquered by the Spaniards. This method of securing fodder was followed by the early colonists and continued to be the common method until late in the nineteenth century. It is largely followed in Italy, and is still practised in many parts of the South.

Before topping corn it is necessary to allow the ears to pass the silking period in order to secure fertilization. If done before this the grain fails to develop. Soon after fertilization has been accomplished the silk rapidly turns brown, and when the kernels have past the milky state the corn plant is ready to top.

The topping was formerly done by a man who, with a sharp knife, past along the row of corn and cut off the top just above the ear, and also stript the leaves from that part of the stalk left standing in the field. The parts cut off were laid in small piles to dry and were afterwards tied into bundles. The bundles were set up in little shocks and left until the fodder was sufficiently cured, when they were hauled away and stacked near the feeding place. This feed was considered very valuable and was used for feeding the horses and oxen in the spring before the grass came, when the work-animals had the hardest labor of the year to perform.

In regard to the advisability of topping corn, the Pennsylvania Station[a] found that, by topping, 1,050 pounds of fodder was obtained, at a loss of 540 pounds of ear corn, as compared with allowing the corn to ripen and merely gathering the ears. The Mississippi Station,[b] as a result of a three years' trial, found the net loss in feeding value more than 20 per cent. Seven other stations show an average loss which was "more than the feeding value of the fodder secured."

At the Arkansas Station[c] neither topping nor pulling reduced the yield so much as cutting and shocking the whole plant when the ears were just past the roasting-ear stage, as shown in the following table:

Effect of method of harvesting corn on the yield of grain.

Method of treatment.	Yield per acre.		Loss per acre.
	Pounds.	*Bushels.*	*Pounds.*
Left standing till ripe	1,241	22$\frac{1}{7}$	....
Topt above ear	1,224	21$\frac{5}{7}$	17
Leaves stript	1,102	19$\frac{5}{7}$	139
Stalks cut and shocked	1,075	19$\frac{1}{5}$	166

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[a] Pennsylvania Sta. Rpt. 1891, pp. 55–60.

[b] Mississippi Sta. Bul. 33, p. 64.

[c] Arkansas Sta. Bul. 24, p. 120.

PULLING OR STRIPPING THE LEAVES.

Thruout the Southern States the leaves of the corn plant dry up before the ears are mature, and the custom prevails of stripping the leaves from the stalk while they are still green and the ears immature. At least 8 experiment stations in the Southern States have investigated the influence of this practise on the yield of corn and in general report a decrease of 10 to 20 per cent. The earlier the work was done the greater the loss. Redding, of Georgia,[a] concluded that "pulling fodder" is only expedient under the most favorable circumstances; but where it is done the best practise is to strip the blades, from and including the ear blade downward, at about the usual time of pulling, and in a week or ten days to cut off the stalks above the ear. Besides adding largely to the yield of stover this method is believed to be more expeditious.

The Florida Station[b] reports that "pulling fodder" has the effect of loosening the husks on the ear before the grain becomes hard, thus promoting the ravages of the weevil.

CORN CUTTING WITH KNIVES.

The unsatisfactory results which followed when corn was topt or stript, together with the extension of corn growing, led the farmers to seek a better way of securing fodder. This was found in the method, continued to our own time, of cutting the stalk close to the ground at a time when no damage is done to the ripening grain and while, at the same time, considerable of the saccharine juices still remain in the stalk.

The implement first used for corn cutting was the hoe, or something akin to it, and it continued to be used as late as the beginning of the nineteenth century. This was rather heavy and awkward to handle and the work of harvesting was slow and exhausting. The more progressive farmers discarded this crude implement and substituted the corn knife.

The diary of one early planter near Philadelphia tells the way in which the corn knife was first used on his farm. "The use of a sharpened blade for cutting corn was first begun by a negro who was rather lazier than the rest and always sought to escape the harder labors of the farm. He wrapt one end of a broken sithe blade with a cloth and, using this for a handle, was able to cut three times as much corn as he had cut with the hoe, and that with less fatigue."

Many kinds of blades were used for the purpose, but among them the sithe blade was most largely employed. It was customary to cut these blades in two parts. The knife made from the point of the sithe was considered the better. It was somewhat lighter in weight than that made from the shank end, and of better shape. Sometimes a shank was made by beating and hammering the upper end of the blade into proper shape, and sometimes by cutting away the thin part of the blade for a few inches. By many these old homemade knives are much preferred to the factory-made knife now almost universally used. The factory-made knives are of all sizes and shapes. The corn hook (fig. 1) now extensively used is generally considered even more convenient than the corn knife.

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[a] Georgia Sta. Bul. 23, pp. 81-82.

[b] Florida Sta. Bul. 16, p. 8.

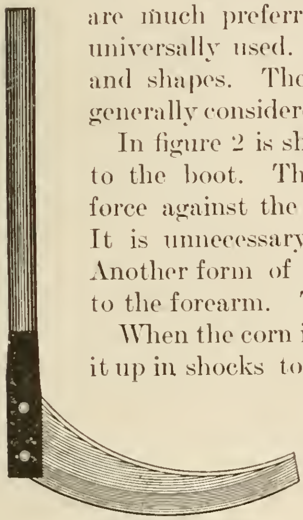
FIG. 1.—Corn hook.

In figure 2 is shown a form of corncutter which is fastened to the boot. This implement is pushed with considerable force against the stalks, severing them close to the ground. It is unnecessary to stoop over the work when using it. Another form of this implement is made so as to be fastened to the forearm. This form is very convenient for topping.

When the corn is cut with a corn knife, it is customary to set it up in shocks to cure. Shocks vary greatly in size, ranging from 6 hills square (36 hills to the shock) to 16 hills square (256 hills); a very common size is 12 hills square (144 hills). Shocks of the smaller sizes are common in the North Atlantic States, where, according to the Connecticut Station, it is more difficult to preserve flint-corn stover; while 10 hills square and 12 hills square are common sizes in the North Central States. A common method is to tie the tops of 4 hills together as they stand, and then to cut and shock the rest of the plants around these. This form is called a four-saddle shock. Another method of making the shock is to use a wooden horse as a temporary support. In either case the shock is built around the support with great care to prevent it from being blown over by heavy winds or damaged by rain. In some cases the corn is tied into small bundles which are set together to form the shock; more commonly the stalks are gathered as cut and set up an armful at a time. Where the wooden horse is used, the shock is built about the horse by leaning the first bundles or armfuls against a pair of projecting arms formed by inserting a pole thru a hole bored at right angles to the horse (fig. 3). When the shock has been set up the pole is withdrawn and the horse removed. When completed, the shock is tightly tied near the top. In the past shocks have been tied with bark or

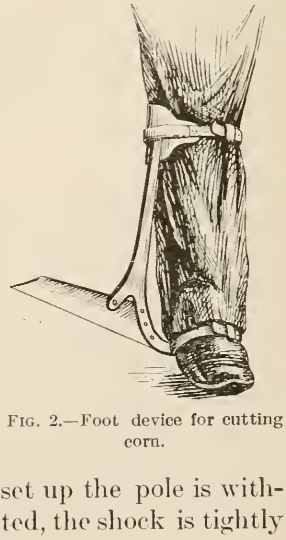
FIG. 2.—Foot device for cutting corn.

grass, or more commonly by means of a stalk of corn or two stalks twisted together; but now since twine has become cheaper it is extensively used. A rope with a hook at one end is sometimes used to draw the tops together before tying. Sometimes shocks are allowed to stand without being tied.

After the fodder has become cured, which usually takes about a month, the shocks are generally husked by hand in the field, and the stover is commonly tied into bundles, tho this is by no means a universal practise. The stover is then shocked up again. Frequently the stover from two or more shocks of corn is put up in a single shock. For convenience in husking a movable table is sometimes used, on which the stalks are laid while being husked. The ears are thrown in piles on the ground near the shocks, and afterwards hauled to the crib. The stover is sometimes hauled to the barn and stored but often it is left standing in the field till needed for feeding during the winter.

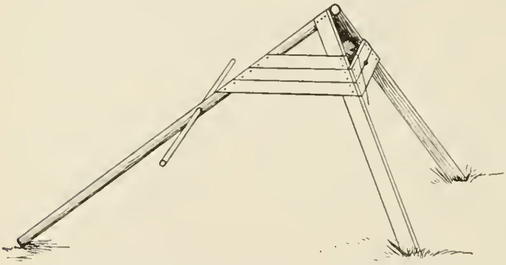

FIG. 3.—Wooden horse used to support shock.

It is important to choose suitable weather conditions for husking, since if the plants are too dry the stalks will break and blades will fall off and be lost. On the other hand extremely wet weather makes the ground too soft for hauling in the corn.

The cost of these methods of caring for the corn crop varies with the locality and the year. Taking the average of the replies to 200 inquiries, it has been learned that one man is able to cut and shock by hand about 34 shocks 12 hills square, or nearly $1\frac{1}{2}$ acres of corn per day. The average cost per shock for cutting by hand is 6.5 cents, or $1.50 per acre.

The advantage of cutting the cornstalks and allowing them to cure in the field is strikingly illustrated in an experiment conducted at the Georgia Experiment Station.[a] One acre of land was laid off into 52 4-foot rows, and planted in corn. From 20 of these rows the leaves were pulled and carefully cured and weighed. This required the labor of four men during two hours, the cost being 40 cents, or $1.04 per acre. On the same day 16 rows were cut and shocked, which required the time of four men one hour, the cost being only 20 cents, or $0.65 per acre. The remaining 16 rows were left untouched until the ears were fully matured, when they were husked and the stalks were cut and weighed. On the same day the ears of the other lots were husked and weighed, and all the fodder was cut, weighed, and shredded. The following table gives the result of the experiment:

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[a] Georgia Sta. Bul. 51, pp. 280–281.

Results of harvesting corn by different methods.

How harvested.	Shelled corn.	Blade fodder.	Stover.	Total value of product per acre.
	Bushels.	*Pounds.*	*Pounds.*	
1. Blades pulled; stalks harvested	47.24	585	2,012	$35.18
2. Blades pulled; stalks not harvested	47.24	585	....	27.13
3. Stalks cut and shocked	[a] 48.74	....	3,037	39.55
4. Ears husked and stalks cut when dry	45.43	....	2,195	31.49

The total values are based on the following prices: Shelled corn, 50 cents per bushel; naked, weather-beaten stalks and husks shredded, 40 cents per hundredweight; the stover, including stalks, blades, and shucks from the shocks, 50 cents per hundredweight; cured corn blades, 60 cents per hundredweight.

The plats on which the stalks were cut and shocked yielded 1.5 bushels more than plats on which blades were pulled, and 3.31[a] bushels per acre more than the plats on which the stalks were left untouched.

In discussing the experiment, Professor Redding says:

> The economic results are so strikingly in favor of the cutting and shocking method of harvesting the corn crop that there can be no further doubt of its great economy.
>
> The results of the foregoing experiment confirm the experience gained in the last five years in regard to methods of harvesting corn, and strengthen the conclusion already reached, that it is much more economical to cut the stalks down and shock them than to pull the fodder in August or to husk the ears in September or October.

MACHINES FOR HARVESTING CORN.

SLED HARVESTERS AND SIMILAR DEVICES.

As early as the year 1820 attempts were made to construct a mechanical corn harvester. From that year until 1892 all attempts to perfect such a machine were unsuccessful. The machines invented were patterned after the mower and the reaper, but owing to the size of the corn plant these machines either would not cut at all or were soon broken under the heavy strain. Some of the machines, however, had commendable mechanical features which were embodied in machines invented later.

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[a] The larger yield of shelled corn from the plat that was cut and shocked should not be counted in favor of that method of harvesting. It is explained as follows in the Georgia bulletin just cited: "The increased weight of grain for the plats on which the stalks were cut and shocked can be credited to the fact that the ears left on both the other series of plats were drier, because fully exposed to the sun and wind. The cause of difference was overlooked at the time and until too late to remedy. * * * No gain in the weight of grain from the cut and shocked plats was expected, and the results would have been entirely satisfactory had there been a small loss as the result of cutting down the stalks."—EDITOR.

Many homemade harvesting devices of the sled pattern have been made from time to time, some of which are illustrated in figures 4, 5, and 6. The first harvester of this class was patented by J. C. Peterson, of West Mansfield, Ohio, who put one in the field in 1886. Others followed and added improvements until eight or ten harvesters of this kind were in the field.

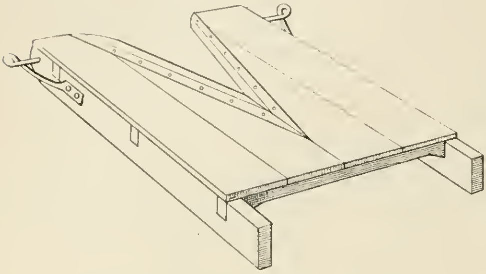


FIG. 4.—One-row sled harvester.

With most of the sled harvesters the driver rode on the platform, and it was necessary for him to gather the stalks in his arms in advance of the cutting edge, so as to prevent them from falling in various directions. This method of harvesting was very exhausting. The harvester shown in figure 6 was an improvement, in that the guiding arm collected the stalks on the platform and it was only necessary for the driver to pick the stalks from the sled at intervals and throw them on the ground. As an improvement, in order to reduce the draft, the sled was mounted on wheels (fig. 7). This machine cuts two rows at a time, and two men sit on the platform, one facing each row, to guide the corn against the cutting edge with one hand, and with the other hand and arm to collect the cut corn on the tilting-side part or wing of the platform, drawing it back against the leg, where it is assembled until enough has been collected to form a shock. The stalks are then tied together into a small shock, and the side platform is so tilted as to deposit it upon the ground in an upright position. This form of corn harvester is still used quite extensively. It has automatic knife guards by which the cutting edge of the knife is covered with a plate of steel when the machine is not in use. This lessens the danger of injury to men and animals, which often happens when the cutting blades are left exposed. The tilting parts or wings of the platform

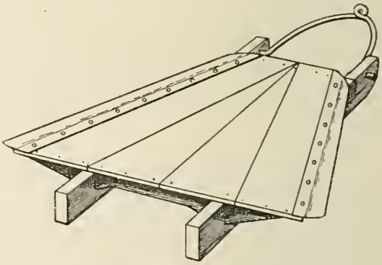


FIG. 5.—Two-row sled harvester.

may be raised into a vertical position to pass obstructions, or may be folded back against the seat standard. The wheels can be adjusted to cut corn high or low.

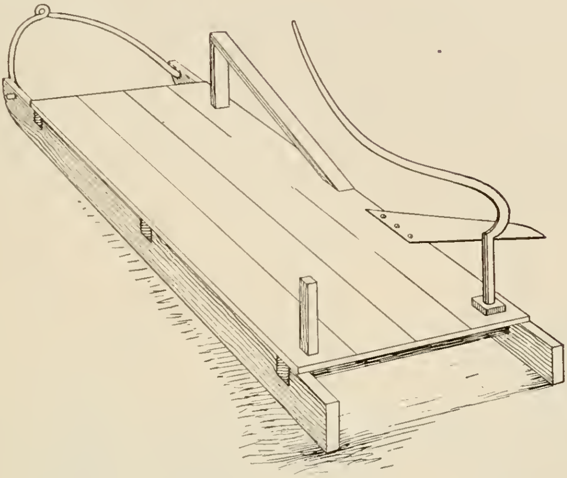


FIG. 6.—Improved one-row harvester.

To reduce the labor involved in cutting corn with the machines described, another form of corn harvester was invented, as shown in figures 8 and 9. This machine consists of two driving wheels, between which is mounted the frame for the driving mechanism and platform. It is drawn by one horse, which walks between the two rows that are cut at the same time. The dividers pick up the lodged corn, except

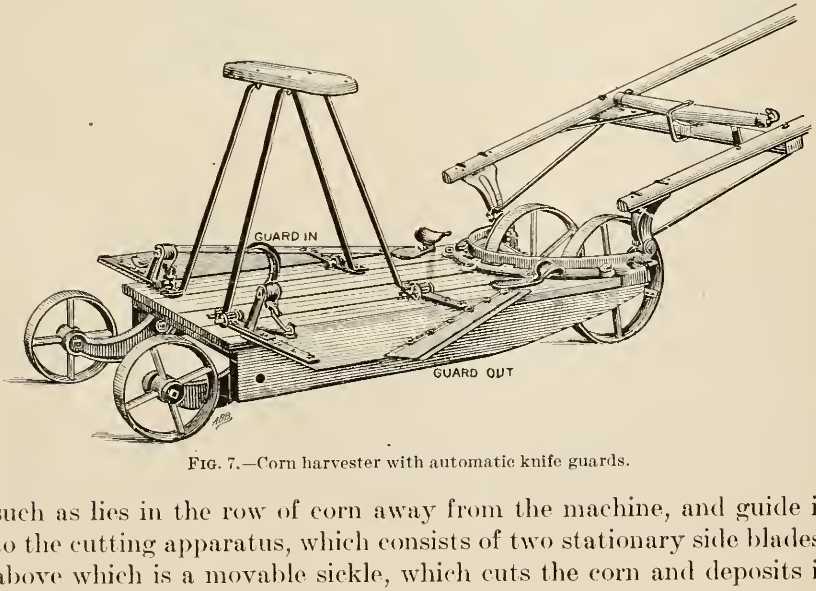


FIG. 7.—Corn harvester with automatic knife guards.

such as lies in the row of corn away from the machine, and guide it to the cutting apparatus, which consists of two stationary side blades, above which is a movable sickle, which cuts the corn and deposits it horizontally on a platform that is elevated about 6 inches above the cutting apparatus. On the inner side is a guide chain, which assists in directing the stalks of corn to the knife and the platform. The rear part of the machine is provided with a small wheel, above which is a tilting lever, by means of which the dividers in front can be raised or lowered to gather up the lodged corn until it comes in contact with the endless chain, which carries it backward until it is cut and deposited on the platform, as shown in figure 9. The machine shown in figure 8 has low wheels and stationary cut, while the one shown in figure 9 can, by means of side levers, be adjusted to cut the corn from 2 to 15 inches from the ground.

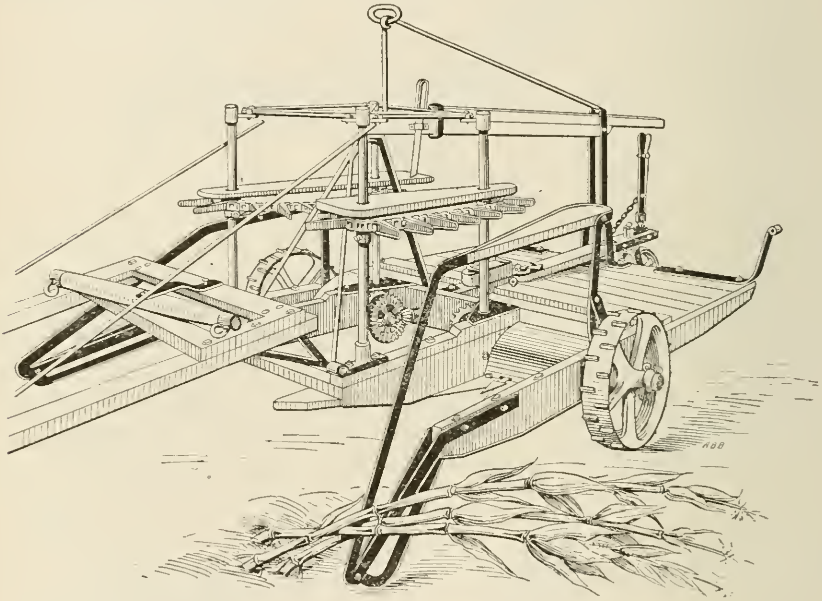


FIG. 8.—Two-row corn harvester with stationary lift.

Machines of this type gather and cut the corn and drop it on the platform. When there is enough to start a shock the horse is stopt and the two men who follow the machine gather the corn from the platform and set it up around the shock pole and tie it. They then start the horse again, and when returning across the field the horse is stopt opposite the shock, to which more corn is added, and this is continued until the shock is of the desired size. When the shock row has been started the shock pole is pushed in so as to be out of the way (fig. 8) while the balance of the corn is being cut. This will save carrying the corn around the pole. The machine may also be backed up to the shock instead of the corn being carried to it from the machine.

The sled harvesters and corn harvesters of the same type vary in price from $5 for the simpler forms, which are made at home by the farmer, to $55 for the more elaborate machines as shown in figures 8 and 9. These harvesters have one great advantage over the more complicated machines in that the first cost is low. For this reason every farmer, even with only a few acres of corn to cut, can afford to have one. It requires but one horse for motive power, and very little if any twine is used to tie the shocks. However, if the corn is tangled or lodged the cruder forms of these harvesters can not be used, as the corn must stand straight and the horse walk rather fast in order that the harvester may do perfect work. It is also rather hard work for the men to gather and shock the corn. The work of harvesting corn is such that only the best construction can withstand the strain for any great while, and hence these machines are being used less than formerly, even in those sections of the country where they were once extensively introduced.

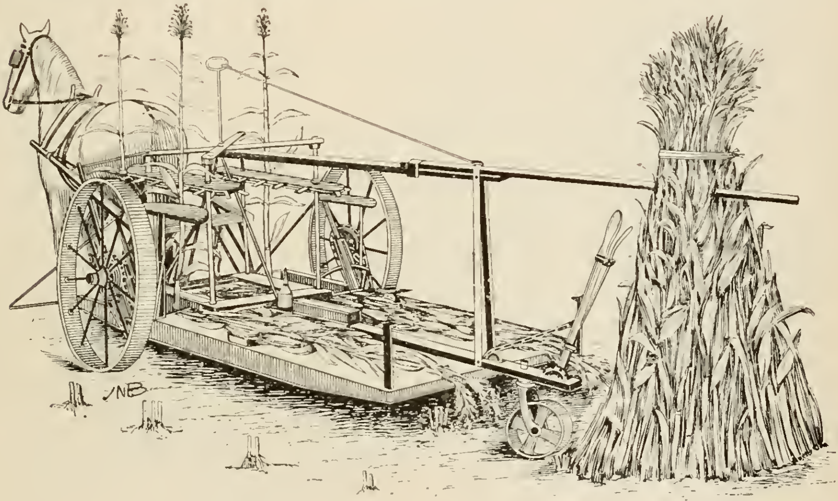


FIG. 9.—Rear view of two-row corn harvester.

In regard to the cost of harvesting corn with these machines the following questions were sent out to numerous farmers in various sections of the country where corn is raised:

1. With a sled harvester, how many acres of corn can be cut per day?
2. How much does it cost per acre to harvest corn with a sled harvester? (*a*) Cost of machine——. (*b*) Driver and team ——. (*c*) Twine ——. (*d*) Extra shocker ——.

From the 90 replies received in answer to these questions, it was learned that the minimum in acreage of corn cut per day is 2 acres, and the maximum 10 acres. The average from all the replies received equals 4.67 acres of corn which can be cut per day by two men and one horse using the sled harvester.

In reply to the question as to cost per acre for harvesting corn, the minimum price reported was 55 cents per acre and the maximum $2. Taking the average of all the replies received, the cost of harvesting corn with a sled harvester is $1.18 per acre. This is estimated on a basis of 18 cents per acre, or 84 cents per day for the use of the machine and repairs; 4 cents per acre, or 19 cents per day for twine; 58.5 cents per acre, or $2.75 per day for one horse and a man who does part of the shocking; and 37.5 cents per acre, or $1.75 per day for the other shocker. Comparing this cost per acre with that of hand cutting (p. 46), it will be noted that there is a saving of 32 cents per acre in favor of the machines. It will also be noticed that two men and a horse, with a sled harvester, can cut and shock 4.67 acres per day as against 1.47 acres per day for one man with a knife, which gives a credit of 1.73 acres per day for the work of the horse, or a considerable saving in favor of the machine. The work may thus be done quicker than by hand, which is of importance, as the corn plant should be cut promptly just when it is ripe in order to obtain full benefit of all its nutrients.

CORN BINDERS.

HISTORICAL.

The credit of inventing corn-harvesting machinery belongs to Edmund W. Quincy, of Illinois, as he obtained the first patent on a corn-harvesting machine in October, 1850. "Old Father Quincy," as he became well known thruout the country, spent more than forty years of his life in efforts to produce a machine to pick corn, and during most of that time he lived in abject poverty, wandering from place to place pursuing the will-o'-the-wisp of promised assistance, using the money tossed to him as alms to construct his crude machines or to remedy their defects, going for days without food or shelter, faithful to his cherished plan until the end. His machine was essentially a field picker. Many other inventors worked like Quincy, on the idea of a machine to pass over the row and pick the ears from the stalks.

Another form of corn harvester (fig. 10) was invented in the "eighties." This machine cut the cornstalks and elevated them into a wagon, which was very convenient when the fodder was to be used for ensilage. The elevator could be removed and a binder attachment put on by which the corn was bound into bundles, these being left in the field to cure.

One of the earliest forms of corn harvesters and binders was constructed as a modified form of the grain binder. This machine also was so constructed that for the binder attachment a device might be substituted to elevate the corn into a wagon.

The principle in corn harvesters and binders which was destined to prevail was invented by A. S. Peck, of Geneva, Ill., and patented January 5, 1892. It consisted of a corn harvester with the two dividers passing one on each side of a row of corn, which was cut and carried back in a vertical position to the binder attachment by means of chains and gathering arms. A standard twine binder was used, set in a vertical position so as to receive the stalks and keep them in this position until the bundle was discharged. The horses were hitched behind the machine the same as they are on the header or push binder. The machine is shown in figure 11, in operation in the field.

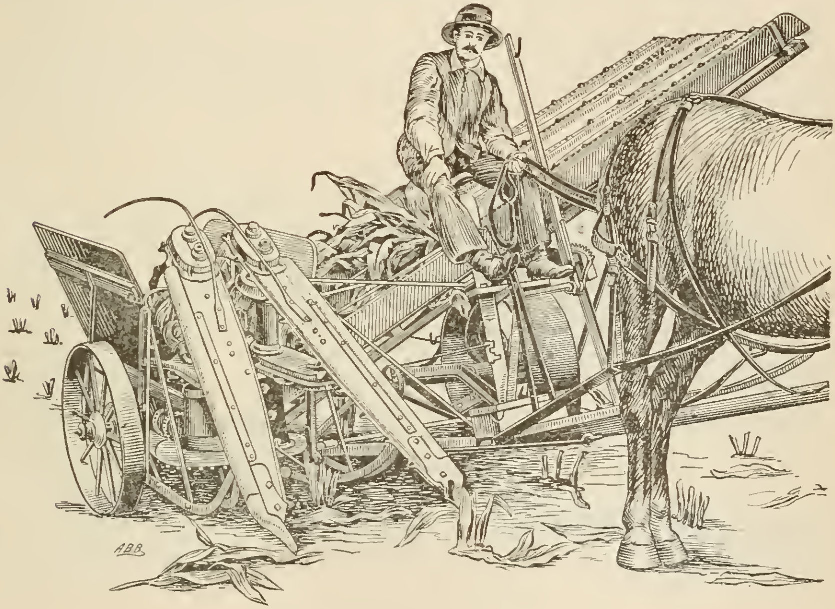


FIG. 10.—An early corn harvester.

The Peck patent received very little attention at first. It showed very few elements that were new, as the vertical principle of cutting grain had been tried and failed to give satisfaction. It was rather a rearrangement of well-known principles used in harvesting machinery than a new departure. Still it was the collection of these principles in proper form which produced a successful machine. After two years' use by the inventor and a few other persons, its merit was recognized by one of the prominent harvester manufacturers.

In the perfection of farm implements there are usually two stages of development. The first covers the conception of the idea and the making of an implement that does its work satisfactorily in the hands of the inventor. The second stage covers the pioneer efforts to manufacture it and to introduce it into general use. The period from the first invention of the corn-harvesting machine by "Father Quincy" in 1850, until 1895, may be considered as covering the first stage of the development of corn-harvesting machinery, in which many machines were made that would work well in the hands of inventors; but almost half a century was required for the designing and perfecting of these machines so that they might be manufactured for general use. During this time much capital was lost in fruitless efforts.

Since 1895 the self-binding corn harvester has had a considerable sale. In practically all of the corn binders now built the features of the Peck type predominate. Even the most divergent forms still retain the general organization of parts used in the Peck machine.

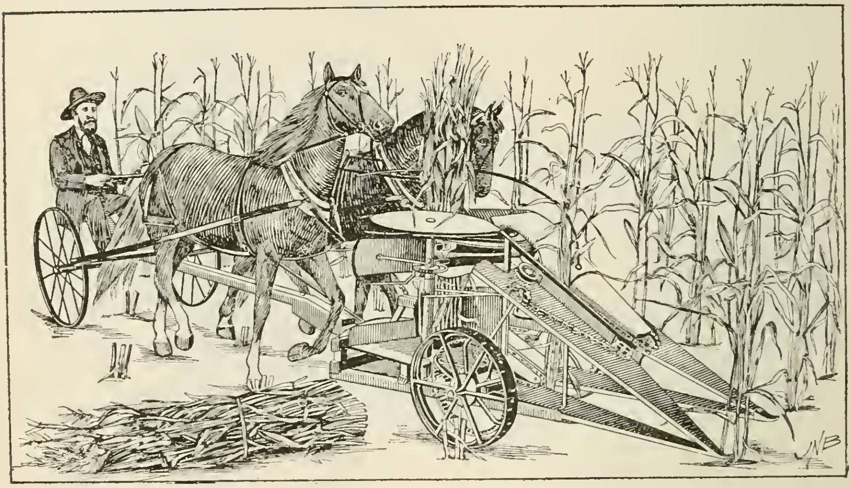


Fig. 11.—Vertical corn harvester in the field.

Among the practical and successful corn binders in the market the widest divergence from the Peck type is probably to be found in the machine invented by John A. Stone, of Chicago. In this machine the binder is in an almost horizontal position, instead of vertical. When the corn is cut the stalks move a little rearward in an upright position, and then they are tripped so that the tops fall rearward onto an inclined deck, being guided in their fall toward the binder by curved guide arms. The butts are pushed out of the way of the incoming cornstalks, and are evened for a bundle by means of a butt adjuster.

A type of corn binder, which comes about halfway between those already described, was invented by Tarrall and Maul, of Batavia, N. Y. It is designed to occupy an inclined position over the deck for the purpose of binding the stalks in a semiprostrate position.

CONSTRUCTION.

There are, therefore, three different forms of corn binder, namely, the vertical, the horizontal, and the inclined, the latter being rather a blending of the two preceding types. These machines differ only in the relative position of their elements, being composed of the same essential parts. Binders consist essentially of the dividers, of which previous mention has been made, and of cutting and binding devices. (See figs. 12, 13, and 14.) A bundle carrier is usually also attached, but this is not essential to the smooth operation of the machine.

DIVIDERS.

The dividers consist of two diverging jaws opening at the front of the machine. The jaws begin in two points at the front, but gradually widen vertically to where they join the frame of the machine, when they have a width, or rather a height, of 4 feet or more. By an arrangement of levers the points may be raised or lowered. Attached to each jaw are two or three traveling chains, whose purpose it is to bring the stalks to a vertical position and carry them back to the binding deck. The chains are placed one above the other (fig. 12). The lower one is known as the short-corn chain, the middle one is the conveyor chain, and the upper one is the tall-corn chain. The middle chain passes around a sprocket wheel close to the point of the jaws, and extends back almost to the binding deck. The upper chain begins farther back and extends some distance over the binding deck. This chain is meant to carry the tops of tall corn. The lower chain is of about the same length as the upper one, begins nearer the point of the jaw, and does not extend so far back. These chains are

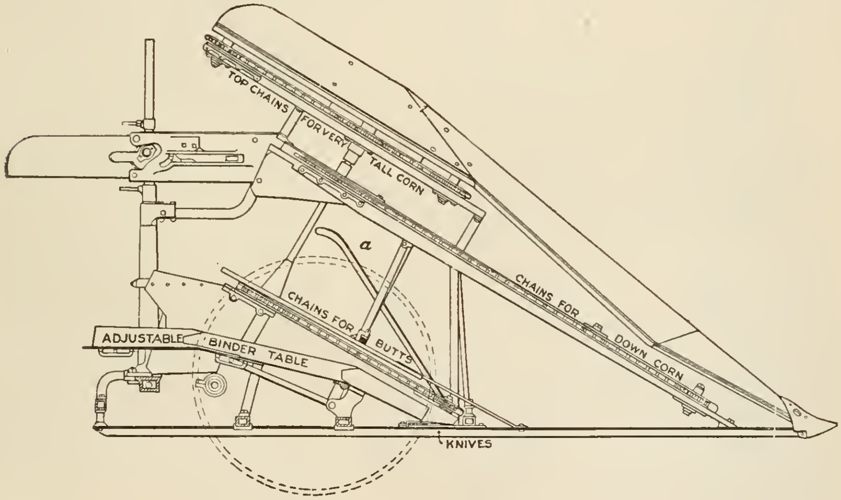


FIG. 12.—Skeleton frame of corn binder, showing chains.

supplied with fingers, which take hold of the stalks and lift them to a vertical position as the machine advances. The jaws have such a position relative to each other as will bring the fingers of the opposite chains almost in touch with each other at or near the cutting blades. The chains receive their motion from the main driving mechanism, and are driven at such speed as will bring the stalks to the proper position for cutting without shaking them too severely.

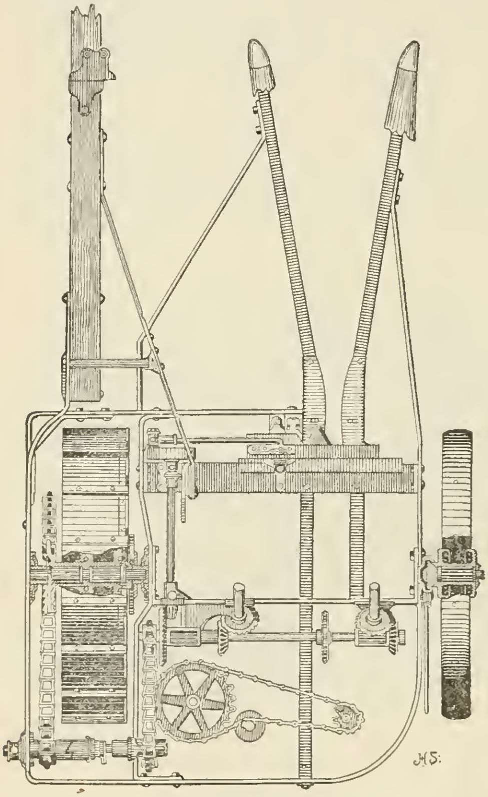


FIG. 13.—Frame of corn binder, showing mechanism for driving cutter knife, gear shaft for driving chains and binding device, and roller bearings.

CUTTERS.

The cutting arrangement consists of a serrated knife which passes to and fro across two stationary blades, one of these being attached to each jaw. This serrated knife is driven by a pitman attached to a weighted wheel called a "fly wheel." The added weight gives enough stored energy to sever the toughest stalks without shock to the small gear wheels (fig. 13).

Attached to the rear of the dividers and extending around the binding deck are several guide springs (fig. 11) which keep the tall corn from bending over and becoming entangled in the binding gear.

BINDING APPARATUS.

Just behind the knife and thence extending back to the bundle carrier, is the butt shoe, or butt carrier (fig. 12). This device carries the weight of the stalks after they are cut. It is fastened to the frame just behind the knife, but thru the rest of its length it is adjustable vertically, so that the binding twine may be placed at the proper place on both tall and short corn.

As the stalks are cut they are carried back by the conveyor chain, with their butts resting in the butt carrier until they reach the binding deck, where they are pushed backward by the packers, which have such a motion as will carry them perpendicularly thru the binding deck and parallel to it while conveying the stalks to the knotter. Their motion is more rapid than that of the chains, but they have the advantage of yielding slightly while a bundle is being tied. This is important, as many ears would otherwise be knocked from the stalks by jamming the stalks behind the needle.

The needle and the knotter form the binding attachments. They are in nearly all cases of the same pattern as are those of the grain binders of the same makes, but are made heavier to meet the requirements of the work.

The packers on these machines (fig. 14) must have such a motion as to travel toward the back of the machine as long as they project above the binding deck, their travel thru the deck being fast and of short duration. There is one machine on the market which does not use packers at all, but has instead several chains with collapsing fingers. While the bundle is being formed, these fingers assume a position perpendicular to their chains, being held so by the guides over which they travel. As soon, however, as the needle moves, these guides no longer bear against the fingers, which collapse when pressure is brought to bear against them. This prevents their jamming the incoming corn against the rib of the needle while a bundle is being tied and avoids the breaking off of ears that would often occur otherwise.

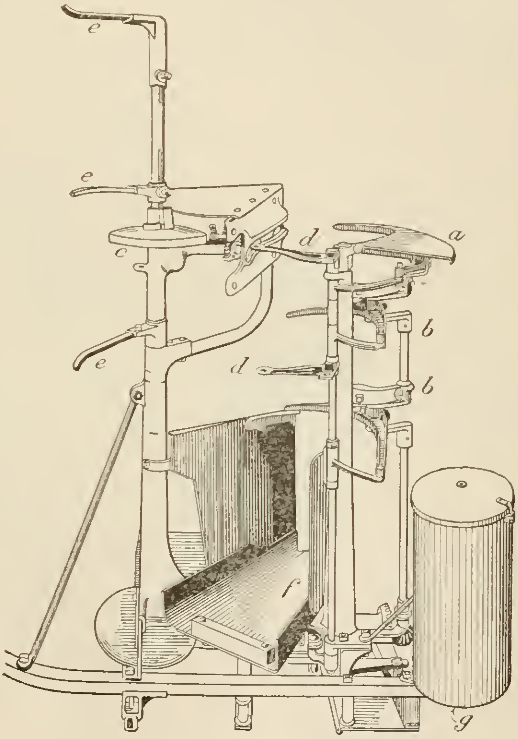


FIG. 14.—Binder attachment: *a*, needle; *bb*, packers; *c*, knotter cam; *dd*, compressor hook; *eee*, discharge arms; *f*, Butt table or butt shoe; *g*, twine cam.

When the bundle has been bound the two or three discharge arms on the binding shaft have reached the back side of the bundle, and by the continuous motion of the shaft the arms force the bundle off the deck and discharge it, after which the compressor hook returns automatically to its place and the binding shaft stops until another bundle is formed, when the operation is repeated. Figure 14 shows the binding mechanism and the general arrangement of the several parts referred to.

The parts that are adjustable by lever are the butt shoe, the dividers, and in some machines, the binding deck and knotter and needle. The whole frame of the machine may be raised or lowered by means of the two worm-and-pinion arrangements, one on the grain wheel and one attached to the main drive wheel.

In the vertical machine the binding mechanism has a vertical position; in the horizontal machine it sits horizontally on the frame, and in the inclined machine it is inclined.

In the horizontal machine it is necessary to extend a conveyor chain farther back than in either of the other types, so as to bring the tops of the stalks into a horizontal position. In this type, too, the bundle carrier extends in a direction parallel to the length of the machine. This arrangement is very apt to give trouble from the butts of stalks becoming lodged in stubble or soft earth and spreading the bundles in disorder upon the ground. This might be avoided more or less by giving the bundle a sharp toss, thus freeing the carrier before any part of it touches the ground. The fingers of the carrier are sometimes made free to move backward and forward so as to prevent the drag above referred to. On the vertical and inclined machines there is less danger of trouble from this source, as the bundle carriers extend across the path of the machine. The smooth operation of the carriers depends greatly on the skill of the operator. Too many bundles crowd the carrier and prevent the binding attachment from properly freeing itself, causing the leaves of the stalks in one bundle to become wrapt about the stalks in another.

The tall-corn chains may be removed where the corn is short or of medium height, and in clean fields of tall corn the short-corn chains are unnecessary. In short corn the lower chain has sometimes proven inadequate alone to properly convey the stalks to the binding deck. By the addition of a small iron rod or spring (shown at *a*, figure 12, p. 19) on each of the dividers, the choking of the binding gear is prevented and a more nearly perfect bundle is made. A short iron bar has also been added on many machines to serve the same purpose. This is usually placed in a horizontal position between the lower and middle chains. The dividers are adjustable vertically, allowing them to pick up corn that is lying flat upon the ground, the lever being in reach of the driver.

To protect the mechanism from the stalks of the uncut rows, a guide rod of hickory or other tough wood is usually attached to the dividers and extended as far back as is necessary. It may be raised or lowered independently of the dividers, however, so as to give protection against either tall or short corn. This bar is shown at the left in figure 15, and the tilting lever on the right.

Badly tangled fields make the progress of one of these machines slow, but it is remarkable with what precision the chain conveyors right the stalks. The adjustment is accomplished by tilting the machine forward or backward by the tilting lever, according to whether it is desired to lower or raise the points of the dividers. As the weight is almost evenly distributed on either side of the main shaft, it takes but a very little power to bring the dividers into the desired position.

There are two types of these dividers—the vertical (see fig. 11, p. 18) and the inclined (fig. 15). For the vertical it is claimed that little jostling is given the corn, decreasing the danger of knocking off ears, while advocates of the inclined pattern claim to accomplish the same result by allowing the stalks to recline against the inner jaw and be carried backward between the fingers of the conveyor chain on that side.

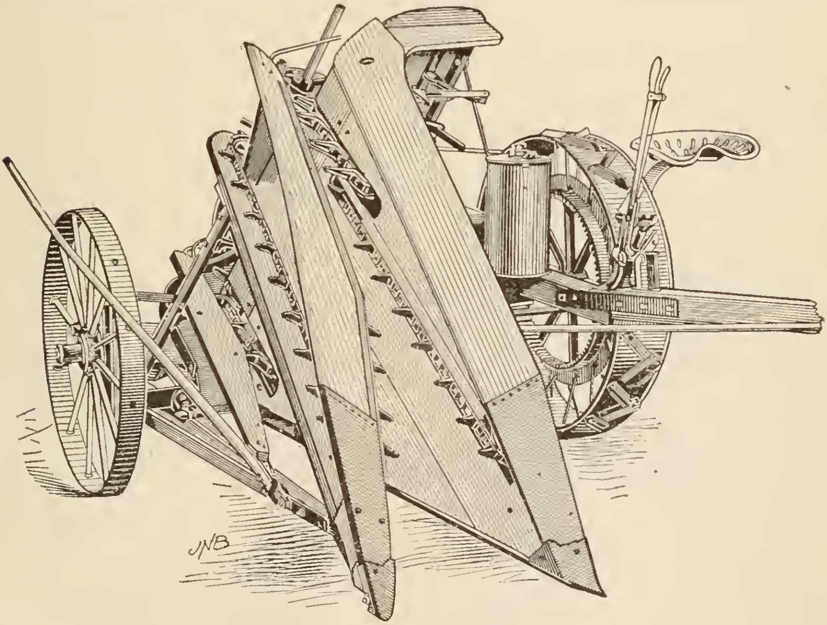


FIG. 15.—Inclined corn binder, showing tilting lever and guide rod.

Owing to the great variation in height of corn, even in the same field, the binding attachments are given great range of operation. In some machines they are placed as high as 32 inches. On machines of this range it is customary to have two needles, each covering half of the variation in the position of the knotter. With such a large range as this it is possible to tie the bundles sufficiently low without raising the stalks any great distance, thereby reducing the work required of the machine. In most machines the motion is taken from the inside; in some, however, it is taken from the outside hub of the main driver (see fig. 13, p. 20). . The arrangements for reducing friction and excluding dust from the bearings receive careful attention, as may be noted from the numerous roller bearings and brass-bearing boxes. Gears are also protected wherever possible, to prevent wear from dirt and grit. Where gears are not properly protected and oiled there is apt to be a great loss of power, to say nothing of the wear. When they receive careful attention, however, the power required to move them is reduced considerably below that required for chain and sprocket. The driving power is increased by means of lugs cast or riveted on the rim of the main drive (fig. 15). They are made of various shapes, the object of all being to sink into the earth in such a way as to prevent slipping. Tubing, angle iron, and bar iron are used almost exclusively in the construction of the frames. These give strength and lightness, features which are most essential to a perfect machine. The attendant, from his seat on the machine, has perfect control over all parts. The levers at his side operate all adjustments, and the position of the bundle carrier is controlled by a foot-lever attachment.

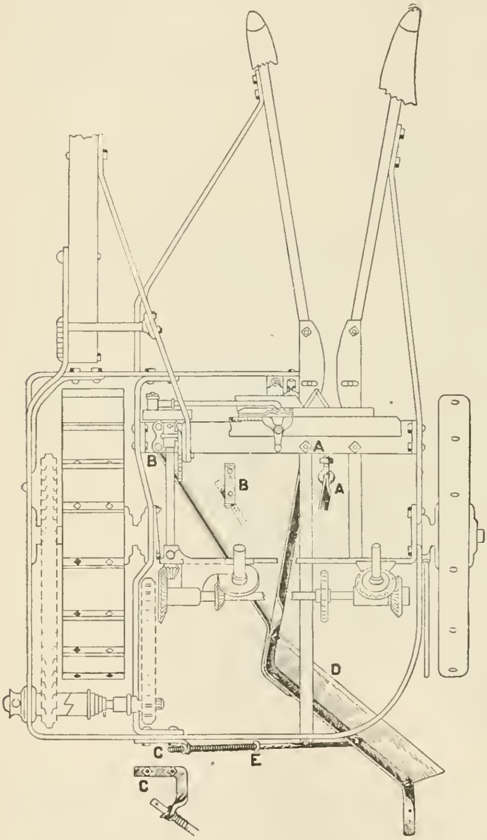


FIG. 16.—Corn-stubble cutter, attached to corn harvester.

These machines weigh, complete, from 1,400 to 1,800 pounds. Generally speaking, those weighing in the neighborhood of 1,500 pounds have been most successful, this weight seeming to give the proper relation between driving power and durability.

The corn binder is used to greatest advantage in fields where the corn is check-rowed, as it is possible to cut around a block, keeping the machine constantly in operation.

When the corn is cut high with a corn binder the farmer experiences considerable difficulty in getting rid of the corn stubble. In order to obtain a clear field and to have the cornstalks cut close to the ground, an attachment has been invented as shown in figure 16. This knife is attached to the underside of the machine and floats on the ground, cutting the stalks even with the surface. The cutter (D) has a drawing, slanting cut against spring resistance (E), making a clean cut. When this attachment is used the binder is usually set to cut higher. The stubs, if cut when sappy, will decay quickly, and are left on the ground to form humus in the soil; and the ground may be prepared for the next crop with greater thoroness.

DRAFT.

The following results were obtained in draft tests of corn binders made by the author at the Iowa State College:

Draft tests of corn binders.

Binder.	Condition of soil.	Empty, out of gear.	Empty, in gear.	Cutting, not binding.	Cutting and binding.	Cutting and binding with rows as cultivated.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
1	Medium soft	351	328	465	480	496
2	Dry	372	415	575	600	592
3	do	290	332	492	496	....
4	do	235	352	463	500	473
5	do	267	298	451	468	448
	Average draft	283	345	489	509	502

The average draft on corn binders is about the same as that of a 6-foot grain binder. The corn binder should, therefore, be propelled by three horses, the same as are required for grain binders. Draft tests of the corn binder, with a stubble-cutter attachment, shows the following results:

Draft of corn binder with and without stubble cutter.

	Pounds.
Draft with stubble cutter	437
Draft without stubble cutter	420
Draft of stubble cutter	17

COST AND EFFICIENCY.

In order to obtain full information regarding the efficiency of corn binders, the following questions were sent out to numerous farmers using corn binders in different sections of the country:

1. How many acres of corn can one man and three horses cut per ten-hour day with a corn binder?
2. How many acres can one man shock per day after a corn binder?
3. How many pounds of twine per acre of corn is used when using a corn binder?
4. What is the life, in years or acres cut, of a corn binder?
5. What is the total cost per acre for harvesting corn with a corn binder? (*a*) Cost of machine ——. (*b*) Driver and team ——. (*c*) Twine ——. (*d*) Shockers ——.

The average results, taken from the several hundred replies received to this letter of inquiry, indicate that for all conditions of corn, the average number of acres of corn cut per day with a corn binder using three horses, is 7.73 acres. The average number of acres which one man can shock per day after a corn binder is 3.31 acres. The average number of pounds of twine used per acre of corn cut is 2.44. The average life in years of corn binders is 8.17, and in acres of corn cut, 668.77. The average first cost of corn binders is $125. The average cost of machine per acre cut, which includes price of machine, repairs, and interest on the investment, is 29 cents per acre; the cost of driver and team per acre cut is 46 cents, or $3.55 per day; the cost of twine is 30.5 cents per acre. The cost of shocking the corn after a corn binder is 44.8 cents per acre. This gives the total cost per acre of harvesting corn with a corn binder, $1.50.

The cost of cutting corn with the corn harvester and binder is, therefore, the same as the cost for cutting corn by hand, and 32 cents per acre higher than the cost of cutting with a sled harvester. This extra cost of cutting with the corn binder over the cost of cutting with a sled harvester may be attributed to the cost of the twine and the interest on the investment in the higher first cost of the corn binder. The corn binder has, however, proved a useful implement, the advantage over the other methods mentioned being the amount of work which can be accomplished per day and the general ease with which the work can be done.

One disadvantage which may be credited to the corn binder is that it knocks off more or less ears of corn, which either have to be picked up by hand, at a cost of about 10 cents per acre, or left to waste or to be found by the cattle after the field is cleared.

Farmers who have not sufficient corn to cut to make it profitable to purchase machines sometimes hire the work done at a rate of 75 cents to $1 per acre for the use of the machine, the driver, and the team. The average cost of cutting given above was 29 cents per acre for the use of the machine, and 46 cents per acre for the driver and team, or 75 cents per acre. The charge for hiring the work done is only slightly above this.

THE CORN SHOCKER.

It is a curious fact that altho earlier efforts were centered upon the construction of the corn shocker, the perfection of this machine was delayed until after the introduction of the corn binder. In the first machines the inventor attempted to engage the stalks by extending rods or springs in advance of the cutting knives, but this did not prove as successful as did the dividers of the corn binder. With these the corn could readily be brought to an erect position and thus made into a perfect shock.

DESCRIPTION.

The present corn shocker was invented in 1888, and a machine was constructed that year by A. N. Hadley. It was built with a frame mounted on two wheels the same as the corn binder, and consisted of a corn-gathering device—revolving reels on vertical standards, the upper bearings of which were arranged for adjustment laterally, and fore and aft. It had as a cutting device two circular rotating cutters operating against each other and cutting the corn as the machine advanced toward it. Behind the cutting device was a circular rotating table 5 feet in diameter, upon which the corn was collected vertically to form a shock. On this table were several radial ribs, which aided in revolving the standing corn. In the center of this table was a rotating shock-forming standard having radial arms, around which the corn was collected. A revolving crane was mounted on the frame and a rope and pulley attached above the shock by which it could be lifted from the platform and deposited on the ground.

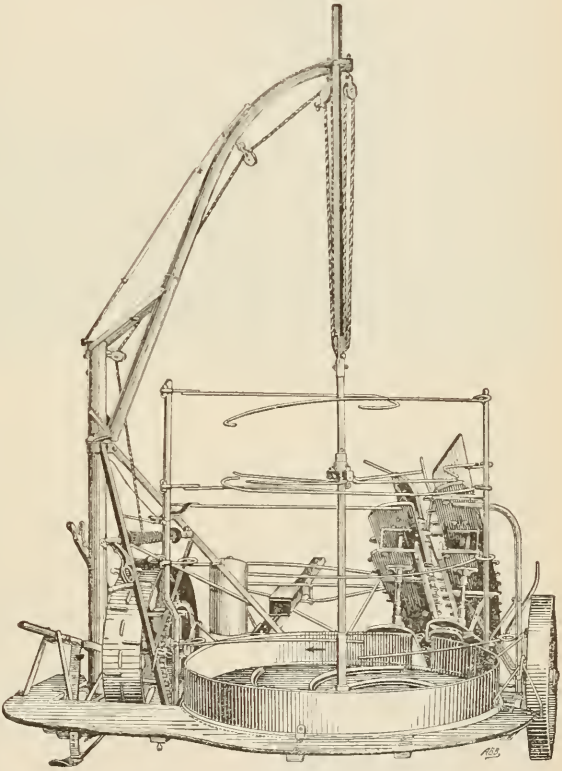


FIG. 17.—Corn harvester and shocker.

In 1893 a shocker was constructed by J. M. Shively, similar in principle but somewhat departing in its construction from the Hadley shocker in that the cutting apparatus and the dividers were like those of the corn harvester, and the retaining wall surrounding the shock-forming table was somewhat higher than that on the Hadley shocker.

The present form of shocker (fig. 17) consists essentially of the dividers already described in connection with the corn binder, a revolving table for assembling the shock, and a crane for removing it. The knives and fly-wheel attachment for cutting the stalks, and the arrangements for raising or lowering the dividers, and the frame are similar to those used on the corn binder. The table revolves in the direction indicated by the arrow, and receives its motion from a bevel gear driven from the main drive and meshing into a rack on the outer edge of the table. As the machine advances the stalks are carried thru the opening in the guard band. They are then caught by the spiral plates and the arms and forced around the central post. The arms also revolve, receiving their motion thru the central pin from a gear located just beneath the table. Their motion is somewhat slower than that of the table. The guard or tension springs keep the stalks firmly compressed about the central post. Sometimes the twine is tied to one of the arms and allowed to assist in bringing the stalks toward the center by being wound about them as the arms revolve. This practise adds to the expense of operating the machine and does not materially improve the character of the work. At the outer edge are posts which support the tension springs.

When the shock is fully assembled on the table it must be tied by hand. The shock may then be raised from the table by turning the crank, and winding the rope about a spool. The shock must be lifted high enough to clear the retaining wall. The tension springs are swung aside and the crank acting on a sector gear swings the shock free from the machine, as shown in Plate I.

The arms (fig. 17), which are held in a horizontal position by the weight of the shock, are released the instant the rope is given slack. This release of the arms is brought about by a unique arrangement of a cam and pawls. When the rope is tight owing to the weight of the shock, the pawls are held in the grooves of the cam because the weight is carried from the pulley. When the rope is given slack the pawls are no longer kept from slipping out of the grooves in the cam, the shock moves thru a small arc of a circle and drops to the ground. The central supporting post is raised to its position on the machine, as shown in Plate I, figure 2. The whole operation of forming, tying, and setting a shock can be done in five minutes. The shocks are somewhat smaller than those ordinarily made where corn is cut by hand or with a binder, averaging about 100 hills per shock, but the smaller size is necessary and makes it possible to reduce the weight of the machine. The smaller shocks also tend to cure more rapidly. The adjustment of the frame admits of the low cutting of the stalks. This results in a greater weight of fodder per acre and leaves a short stubble that is easily turned under at the spring plowing.

COST AND EFFICIENCY.

Corn shockers cost about as much as corn binders and weigh approximately the same. The wear and tear on the shocker is probably not so great as on the binder, and the former has the added advantage of

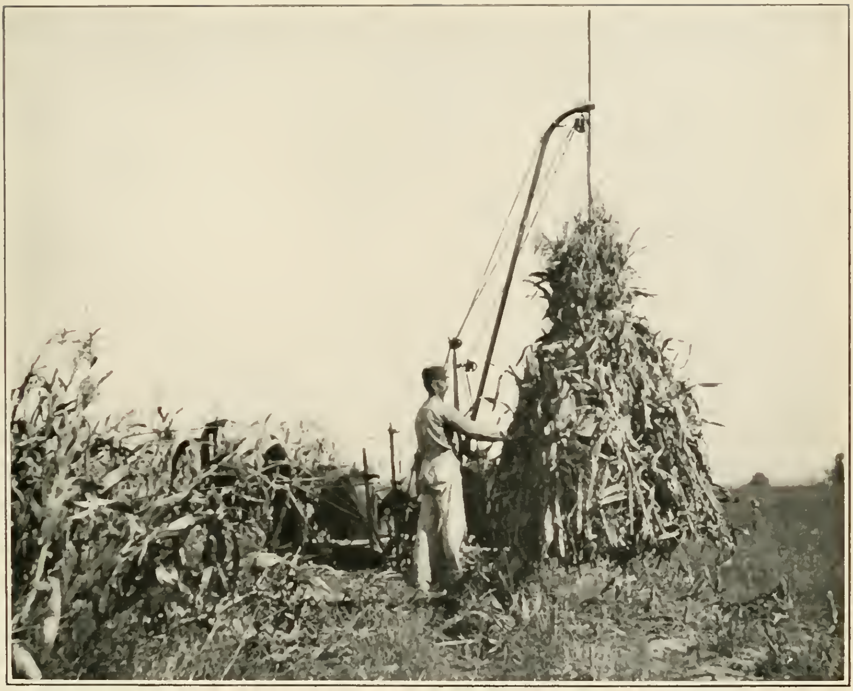


Fig. 1.—Corn Shocker Unloading the Shock.

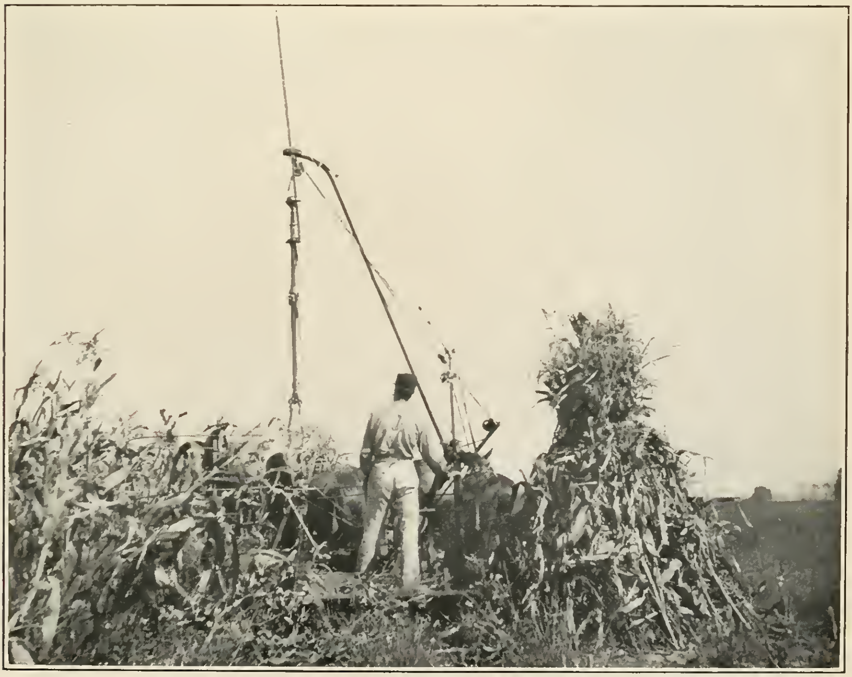


Fig. 2.—Corn Shocker Returning the Central Core.

requiring the work of but one man, whereas the binder requires, besides the driver, two or three men to follow and set up the shocks. The use of a corn shocker removes much of the hard labor of farming. Shocking corn is generally considered hard work and farm hands employed only for that purpose demand a good price for their services.

In order to obtain a comparison between the merits of corn binders and corn shockers for harvesting corn, the following questions were asked numerous users of corn shockers:

1. How many acres per ten-hour day can be harvested with a corn shocker?
2. What does it cost per acre to harvest corn with a corn shocker? (*a*) Cost of machine ———; (*b*) cost of man and team ———; (*c*) cost of twine ———.

From the replies to these questions and from personal knowledge acquired in the field, it has been learned that the corn shocker seems to be the machine that meets the requirements of owners of small farms who do most of their own work. It requires a man of more ability to run a corn shocker than is required in operating a corn binder, on account of the numerous movements that the operator has to go thru, all at the proper time, in removing the shock from the machine. The time of five minutes is about the average required for making the shock, half of this time being occupied in stopping the team, tying the top, lifting the shock, swinging the crane, releasing the core from the shock, and returning it to the table.

Recently patents have been issued for a horsepower lifting attachment for shockers, which consists of a folding tongue, to the top portion of which the whiffletrees are attached. To these is attached a cable, which is wound around a drum, the other end being attached to the lifting device. When the shock is ready to be lifted, a spring catch is released and the horses started forward. The machine remains stationary, but the forward movement of the horses lifts the shock by means of the cable, from the table. When the core has been returned to the table the horses are backed up to their former position, and the spring catch fastens the tongue in place ready for the forward movement of the machine. The addition of such a device will greatly reduce the work of the operator.

In the replies to the questions it is found that the average number of acres of corn which can be cut per day with a corn shocker, three horses, and one man, is 4.7 acres. The life of the corn shocker, in years and acres cut, has not been ascertained, but as the wear and tear is less than on a corn binder, the life of the machine ought to be greater. Assuming that the allowance for first cost, life of machine, and interest on investment is the same as that for the corn binder—i. e., 29 cents per acre; allowing $3.55 per day for driver and team, or 75 cents per acre; and estimating that the twine required per acre cut with the shocker will not cost over 2 cents, we have a total cost of harvesting corn with a corn shocker of $1.06 per acre. This compared with the cost of $1.18 per acre for harvesting with a sled harvester, and $1.50 per acre for corn binders or by hand, gives quite an advantage in favor of the corn shocker.

The manual labor in harvesting corn is the least when using the shocker.

The shock made by the corn shocker is not so easily loaded on a wagon as is that made by a corn binder, as the individual bundles may be loaded with a pitchfork, whereas the whole shock made with a shocker can best be loaded at once, and this requires some form of loading device or horsepower derrick.

The corn binder is well adapted for cutting corn for the silo, as the bundles are bound into convenient size to be loaded on a wagon, thus saving considerable of the work necessitated by handling loose stalks in the field and at the cutter. However, this saving of labor is accomplished at the cost of twine, which remains around the bundles for less than an hour and is a total waste when cut. A corn shocker arranged to load the shocks on a wagon would no doubt prove the cheapest method of harvesting corn for the silo.

The general verdict of farmers who have used both the corn binder and the shocker is that the shocker is the preferable machine for harvesting corn.

A CORN-SHOCK LOADER.

A loading device for handling corn shocks adds greatly to the value of the shocker, for with it the corn can be more cheaply handled than by the present methods. One of the first devices of this kind consisted of a long pole or pipe supported on a fulcrum at the rear end of the wagon in such a way as to give considerable leverage. The idea was much like that of the old well sweep with the semirotary motion added.

An improved loading device which can be carried along with the wagon or left in the field and driven about independently, has been invented (Pl. II). It is mounted on four wheels and consists of an adjustable vertical mast on which is a horizontal steel cross-arm. On this is mounted a traveling block fitted with pulleys, thru which a rope passes. To the end of this rope is attached a horse, which lifts the load. For loading corn shocks, a grapple fork is used, which is slipt under the shock. The grapple arms are closed and with the pull of the horse the shock is lifted up on the wagon and laid on its side or stood on end, the grapple arms being released by simply turning the handle of the fork. This machine was originally designed to load corn shocks, and it easily handles two shocks per minute, and will bear a stress of 2,000 pounds. It can also be applied to many other uses on the farm, as well as commercial uses,

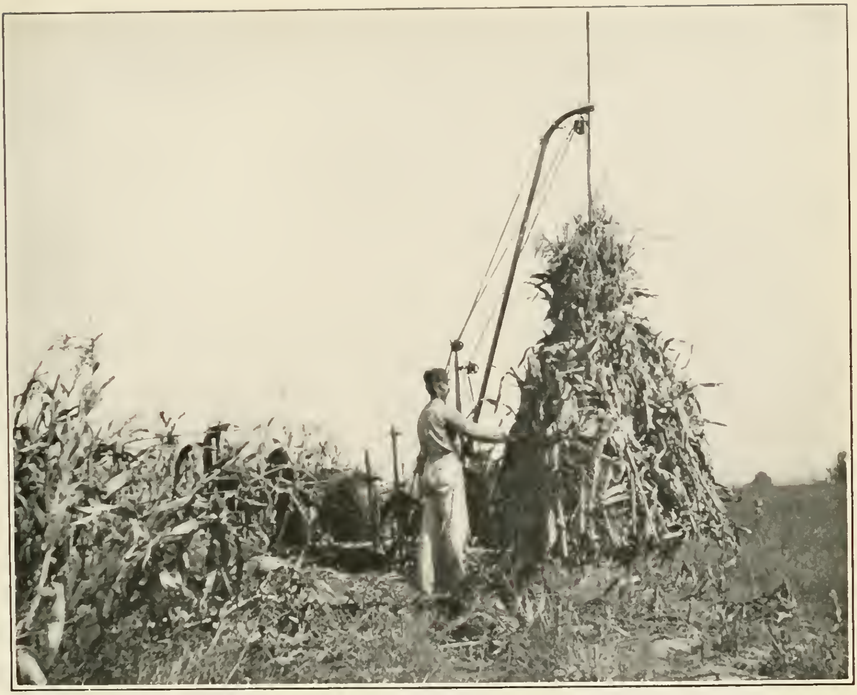


FIG. 1.—CORN SHOCKER UNLOADING THE SHOCK.

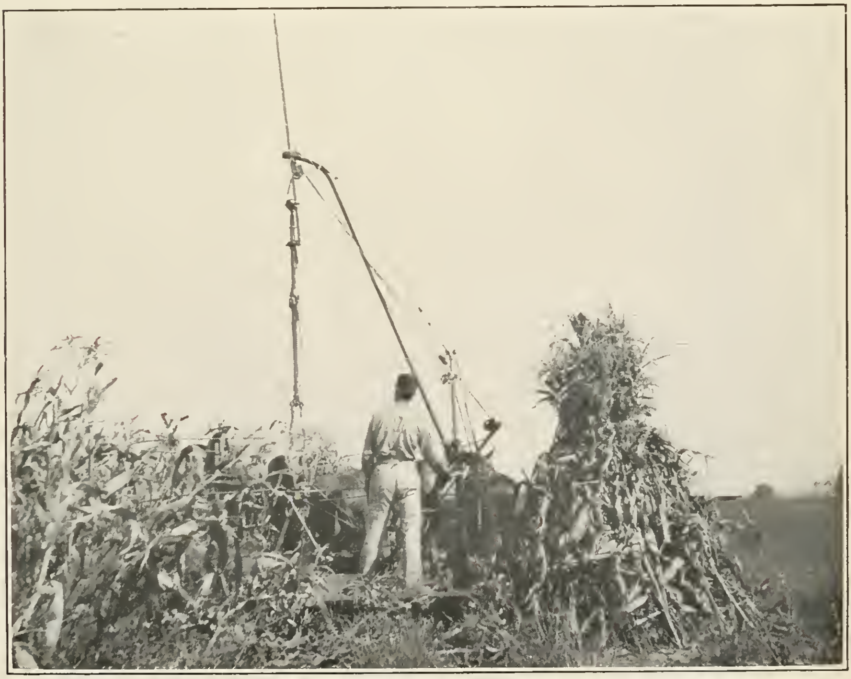


FIG. 2.—CORN SHOCKER RETURNING THE CENTRAL CORE.

such as loading hay, manure, small grain, and other heavy objects on the farm; and for loading dirt, lumber, or telephone poles. Some form of loading device will greatly reduce the hard work on the farm and will be the means of rapidly introducing the corn shocker.

CORN PICKERS.

In the so-called "corn belt," where corn is the principal crop raised, it has not been possible so far to utilize all of the cornstalks, as there is not enough live stock to eat them. The crop is raised for the ears, which are picked by hand at maturity. A wagon is driven along the rows of corn and one or two men walk along the rows, husk the ears from the stalks, and toss them into the wagon. It is estimated that 50,000,000 acres of corn are annually gathered in this way. This is somewhat tedious work. It is usually done after the other fall work on the farm has been finished, at a time of year when the weather is often cold and disagreeable. It is often difficult for the farmers to secure capable men to do this work at the time they are needed, even at good wages. To relieve them, inventors have been busy for over fifty years trying to build and perfect a machine to pick the corn from the stalks.

DESCRIPTION.

The first machine for this purpose was invented by "Father Quincy" in 1850. The picking mechanism of his machine consisted of a revolving cylinder on which were placed four rows of projecting metallic fingers placed at such a distance apart as to permit of the passage of the stalks but not the ears; these were snapt off and were received on an inclined conveyor belt which discharged them into a spout, from which they slid into a wagon driven alongside of the machine.

Only a short time after the Quincy patent had been issued another one was given to William Watson, of Chicago. His machine was somewhat more elaborate than that of Quincy in that it was provided with a cylinder and concave designed to husk and shell the corn. Practically all of the corn pickers consisted of rollers inclining up, in such a way that the front end of the rollers would pass below the lowermost ears and rake the stalk from the bottom to the top. A great many devices were employed for removing the ears, such as cutters, gathering prongs, rotating toothed cylinders, roller and breaker devices, parallel vibrating bars, etc.

All of the early machines were designed to be pushed from the rear and were provided with some form of dividers to guide the corn to the snapping devices, as shown in figure 18. The snapping-roller type of corn picker received serious attention from manufacturers about 1874, when the first machine of this type was invented, but it was ten years later that it was patented. The rollers were placed in the inclined position for the stalks of corn to pass between them. The end portions of the rollers where the stalks entered were provided with bars designed to aid in snapping off the ears as the stalks past down between the rollers during the advance of the machine. For the remainder of their length the rollers were so constructed as to tear the husks from the ears and continuously feed the ears along to be finally discharged, husked, onto a conveyor, and delivered into suitable receptacles. This particular machine was thought to promise success, but when the corn binders began to be developed and came into use the interest in corn pickers abated, as it was thought that with a successful corn binder there would be no need of corn pickers. However, the use of the corn binder and the shocker, while quite extensive, does not solve the corn-harvesting problem in the purely corn-raising regions, where a large share of the corn is still picked by hand from the stalks as they stand in the field.

About 1902 the attention of manufacturers was again turned to corn pickers and several machines are now being introduced for picking corn. The corn picker as now constructed resembles the corn binder in the construction of the main frame, drive wheels, and dividers. It passes along the row of corn, which is straddled by the dividers, and the stalks after being righted by the points, chains, and other devices, pass between a pair of inclined, corrugated rollers that snap or strip off the ears. The rollers are positioned so that the ears fall naturally into a trough that extends along beside them. In order to provide snapping rollers to remove the ears and force them to fall always to the same side, yet permit free entrance of the upright stalks at the receiving end without the necessity of auxiliary means to bend the stalks laterally, James E. Goodhue arranged the snapping rollers in slightly skewed relation, by which the upright stalk may be gradually forced to one side as the picking rolls pass along, and the ears are broken off and directed to one side. The ears are carried back by a traveling conveyor and either delivered to a set of husking

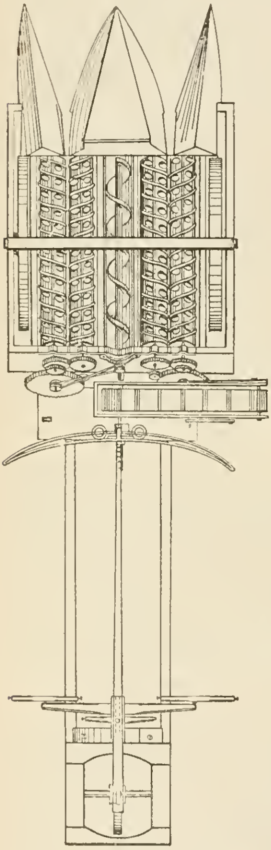
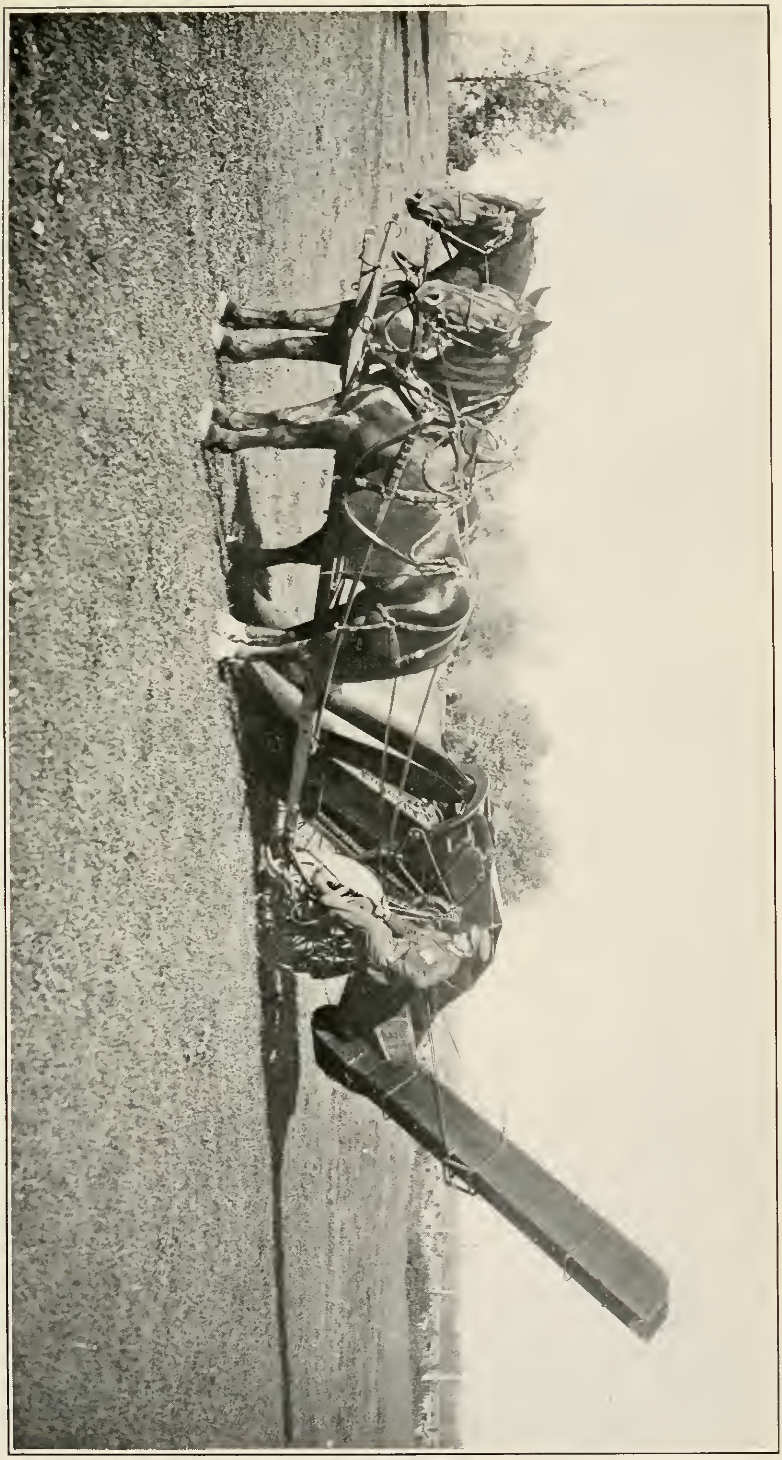


FIG. 18.—A corn-picking machine.

PLATE III.



MODERN CORN PICKER.

rolls or else, without being husked, carried by an elevator and delivered into a wagon which is driven alongside the machine.

Another form of modern practical corn picker has the guide chains with the usual prongs for straightening up the stalks. The chains form a stalk passage extending rearward thru the machine. A rapidly moving chain provided with fingers is located at one side and between the guide chains in such a position that as the machine passes over the row the fingers engage the ears on the stalks and snap them off. By means of a deflector the ears are directed to a receptacle from which they are carried to the husking rollers and thence to the wagon. The tops of the cornstalks are cut off, and by means of a conveyor this and other trash is carried to the rear and dropt on the ground. This machine is shown in Plate III.

OBJECTIONS AND ADVANTAGES.

The corn picker is intended to remove the ears from the stalks, which are left in the field. Most of the machines are built on the assumption that the stalks are valueless, and therefore they are practically destroyed. It has not been possible to construct a picker that will not to some extent break down or tear down the stalks. This is somewhat objectionable because, where the corn is picked by hand, the dried corn leaves and stalks serve as roughage for cattle during the fall and winter. The machine has, however, this advantage, that the field can be picked quicker and the cattle turned in earlier to make use of the roughage before the snow falls.

Another objectionable feature of the corn picker as compared with the hand method of picking corn is that it shells considerable corn; and, if the corn is lodged and tangled, more or less ears are mist by the machine. The corn picker with the husker attachment requires considerable motive power, at least four horses being required to pull it. For this reason some manufacturers have dispensed with the husking attachment and depend upon the snapping rollers for removing most of the husks. Machines of this kind will remove from 25 to 75 per cent of the husks, depending upon the stage of maturity of the corn, the brittleness of the stalks, and the effects of freezing and damp weather. Where machines without the husker attachment are used, a stationary husker may be provided at the crib, in which the corn is husked and elevated into the corncrib.

There is a variance of opinion among the farmers as to the advisability of husking the ears clean. In the South the common practise is to leave the husks on the ears, and it is claimed that this practise tends to prevent injury by insects. In the North it is the common practise to husk the ears clean before they are cribbed.

The objections offered, in reply to inquiries, to using a corn picker which leaves the husks on the ears are that more crib room is required for the ears; that they will serve to attract and harbor rats and mice; that the ears will not dry out, but will be liable to mold; that the husks interfere with the shelling; that, while for feeding cattle and hogs the husks will be advantageous as they will serve as a roughage, horses will toss the ears in trying to remove the husks, and thus lose ear and all. For selling purposes the corn needs to be husked clean in order to command the best market price.

The economic side of corn pickers may be profitably considered. The corn picker should last about as long as the corn binder, or 8.17 years, and pick about the same number of acres per day as can be harvested with a corn binder, or 7.73 acres. The first cost of the machine is, however, practically twice that of the corn binder, or on an average, $250. This makes the cost of machine, interest on the investment, and repairs equal to 58 cents per acre. The cost of driver and team is $3.55 per day, or 46 cents per acre. There is required two wagons with teams to remove the corn from the machine and deliver it into the crib, which, at $3 per day for each, costs $0.77 per acre, or a total cost of $1.81 per acre for picking corn with a corn picker.

To obtain a comparison between the machine and the hand methods of picking corn, the following questions were asked numerous farmers:

What is the average yield of corn per acre in your vicinity?

What does it cost per bushel, including board of men, to pick corn by hand from the field?

How many bushels of corn per day does the average man pick?

From the 300 replies received to these questions it has been learned that the average yield is 44 bushels per acre; that the average cost per bushel for picking corn by hand is 3½ cents, and that the average man picks 59 bushels of corn per day. This yield is considerably above the average given in the crop reports of the United States Department of Agriculture, but it represents the yield of corn in States where pickers are used. Considering now that the number of acres which the corn picker can cover per day is 7.73, this would, for the average yield, be 341 bushels of corn per day. It would require the time of 5.8 men to do the same work in the same time by hand as is done with the machine, at a cost of $11.93 for labor, but in addition to the wages of the men there is need of a team and wagon for every two men who pick corn by hand to haul the corn to the crib. These teams are worth at the very least $1 each per day, or three teams for the 7.73 acres would cost $3. The total cost for picking the same number of acres of corn by hand as can be picked with a corn picker, per day, would be $14.93, or $1.93 per acre, as compared with $1.81 per acre for machine picking. While the saving effected with the corn picker is not large, the use of a machine makes the farmer more independent of the labor market, as the work may be done without hiring extra men at a time when they are hard to secure. But the advantage of hand over machine picking in the removal of the husks should not be overlooked.

The corn picker is still an experimental machine. There are a number of problems to solve before a wholly efficient picker will be produced. The advisability of a farmer purchasing a corn picker is a question which each farmer should decide for himself. He may safely follow this general rule in the purchase of farm machinery and implements of all kinds: A machine newly put on the market, no matter how promising, should not be purchased by a farmer on ordinary terms, because, even with the greatest care on the part of the manufacturer in designing and constructing the machine, weak points in operation and construction are bound to develop, which it will take the manufacturer several years to overcome. Not until the machine has been perfected should the farmer purchase it. It is best to allow the manufacturer to do his own experimenting. If special arrangement is made whereby the farmer is compensated for aiding the manufacturer in developing the machine, that is a different matter.

ECONOMY OF CORN-HARVESTING MACHINERY.

The benefits to the farmer of using modern corn-harvesting machinery have been pointed out, but a question as to when these machines are really profitable should also be considered by the successful farmer, viz, how many acres of corn must a man have to harvest each year in order to make it a profitable investment for him to purchase a corn harvester or corn picker?

We have found that the average life of the corn binder is 8.17 years, and the cost $125. If a man has only 20 acres of corn to cut per year, the cost for the use of the binder for each year would be $15.30. To this should be added $7.20 for interest, making the total annual cost of the machine $22.50. Other expenses for cutting the 20 acres of corn, according to the previous averages derived, would be $9.20 for team and driver, $6.10 for twine, and $8.96 for shockers; or a total cost for cutting 20 acres of corn with a corn binder of $46.76, or $2.34 per acre. We have seen that the work may be done by hand for $1.50 per acre, and that by hiring a neighbor's team and binder at 75 cents per acre, the work may also be done for $1.50 per acre. We may then conclude that a farmer who has only 20 acres of corn to cut per year and does not intend to cut any for his neighbors would lose money by purchasing a corn binder.

If a farmer has 30 acres of corn to cut per year, the annual cost of the machine, including interest, would be 75 cents per acre. It will require a cut of at least 80 acres per year before the farmer can properly estimate the cost per acre for the use of the machine to be 29 cents, as already given. It may, therefore, be concluded as a general proposition that unless this number of acres is available for cutting each year, the investment in a corn binder is not profitable.

These estimates may not be exactly fair, because if the corn binder cuts but 20 acres per year, the life of the machine would probably be considerably longer than eight years. This would in a large measure depend upon the care the machine received. If left outdoors the wear and tear on the machine when not in use would be more than when used. However, with proper care it would last longer, and there is no doubt that in general half the money which our farmers spend for implements could be saved if they gave their implements better care when in use, and when not in use protected them in an implement shed from wind, rain, sunshine, and farm animals.

In the same way we may determine when it is advisable to use a corn picker. The price of these machines ranges from $200 to $325, but if we take $250 as the average price and the average life of the machine and acreage cut as previously noted, the cost per year for the use of the machine would be $30.59, and interest on the investment would be $15. To this should be added about $5 per year for repairs, or a total of $50.59 per year for the use of the machine. In order to make this machine a profitable investment it should husk at least 87 acres of corn each season. Circumstances may alter cases and different conditions change the problem, but in general it is better not to invest in expensive implements unless there is sufficient work in sight to make them profitable.

CUTTING AND SHREDDING MACHINES.

The corn picker should be considered as a temporary machine for emergency use only until such a time as the American farmers will be able to utilize all of the food products grown on their farms. In many instances the great increase in the value of land has brought the farmers to realize that unless more scientific methods of agriculture are adopted and the wastes from the farms stopt, they are not going to realize proper interest on their investments in their farm land and equipment.

One of the serious wastes on the farm in the past has been the neglect of the use of the cornstalks. Thru the efforts of experiment stations the losses from this source have been determined and their enormity pointed out to the farmers. The best method of reducing these losses to a minimum has been found to be thru the use of the silo. It is not within the sphere of this bulletin to go into the details of the advantages of silos or of their methods of construction, but to describe some of the machines used in the preparation of the cornstalks for the silo.

The implements used for harvesting the corn plant have been described. An important matter to be decided in preserving the green-corn fodder in the silo is whether the corn plants are to be put into the silo whole or cut up into fine particles. The advocates of whole-corn silage claim that there will be smaller losses from fermentation with whole than with cut silage. No direct proof is, however, at hand, and the practise followed must be decided by the greater ease of handling the fodder as silage and the relative economy of one system or the other in the opinion of each farmer. The majority of farmers follow the practise of running the corn thru a cutting or shredding machine.

The feed and ensilage cutters used for cutting or shredding corn fodder for the silo and feed for other purposes are of various sizes, from the small hand machine shown in figure 19 to the large power-driven machine provided with self-feeder and blower attachment, as shown in figure 20. The term "fodder shredder" is sometimes erroneously applied to the husker and shredder. There is considerable difference between the two machines. The fodder shredder is similar to the ensilage cutter, being provided with feed rollers of large diameter between which the entire corn plant, ears and all, may pass to be converted into fodder or ensilage, as the case may be; or it can be used to prepare cornstalks for the silo or for fodder after the corn has been husked by hand. It differs from the ensilage cutter in that it is provided with a shredder head, as shown in figure 21, which may be constructed in various ways, but consists usually of a set of saw blades so arranged that they will shred the fodder into fine particles, whereas the cutter head is fitted with knives which cut the fodder into lengths ranging from one-fourth inch to 2 inches. These cutting devices are usually interchangeable, so that the user can put into the same machine either a cutter head or a shredder head, as best suits his needs or preference.

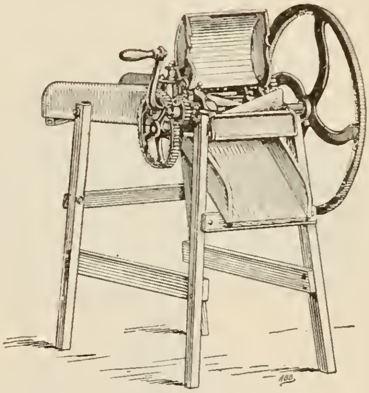


Fig. 19.—Cylindrical feed cutter.

These machines are provided with safety devices so arranged that the feed rolls can be stopt and started at will while the machine is running. This is quite an advantage, as it prevents the sacrifice of fingers, hands, and even of arms. They are also provided with friction safety balance wheels and devices for changing the length of the cut of fodder.

No accurate information is at hand as to the difference in power required for shredding and for cutting a certain number of tons of fodder corn. It is generally conceded that the shredder head requires considerable more power and must run at a higher speed than the cutter, but the recent improvements in shredder heads have materially reduced their necessary speed. Machines of great capacity are now on the market shredding as high as 25 tons of fodder per hour. In the better forms of shredders the feed rollers are speeded at about 160 revolutions per minute, while the cutter heads are usually run at from 600 to 700 revolutions per minute, and shredder heads at about 1,000 revolutions per minute. The power required to run the machines is from 12 to 15 horsepower.

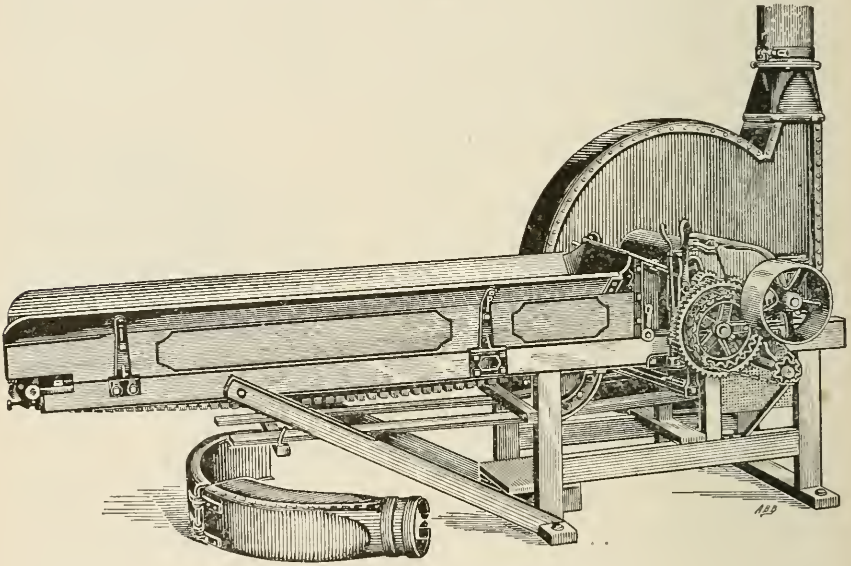


FIG. 20.—Self-feeding ensilage cutter with blower.

The ensilage cutters and shredders were at first provided with swivel carriers driven from bottom, which, by means of metal buckets fastened to a chain, elevated the fodder into the silo or mow. Now, however, most of the larger machines are provided with blowers, which consist of a steel fan inclosed in a case, and a galvanized iron pipe usually 10 inches in diameter, extending to the silo or the mow. The fan is sometimes mounted on the main shaft of the cutter or shredder head and is thus driven by the same belt that furnishes power to the machine. The current of air created by the fan forces the fodder into the place desired. For green silage it is necessary to carry the pipe nearly perpendicular to the height of the silo window and to put an elbow on the top to convey the fodder into the silo. The reason for this is that when the pipe is perpendicular, or nearly so, the force of the wind created by the fan works directly against the force of gravity, which acts upon the silage, whereas when the pipe is slanting the silage tends to collect at the lower side of the pipe and the wind pressure tends to pass over the silage, thus causing clogging in the pipe.

One of the earliest attempts to turn the stalk into feed in any other than its natural condition, or simply to cut it into short lengths by means of a cutting machine, is embodied in a machine patented in 1872, which comprised two parallel gangs of saw-like cutters, between which the stalk is cut into short pieces.

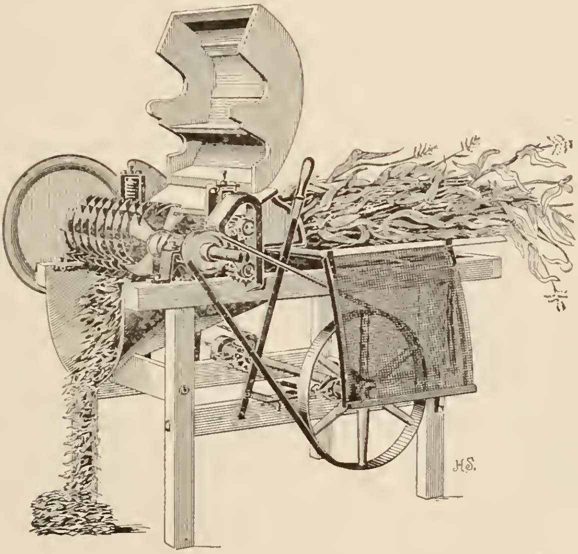


FIG. 21.—Corn shredder.

The modern shredder was first suggested in 1881, as appears from a patent granted to Messrs. Behringer, Stouffer, and Potts, of Pennsylvania. This consisted of two rollers between which the cornstalks were fed to a cylinder provided with knives that slit the stalk and beaters which pounded it, rendering it soft and pliable.

HUSKERS AND SHREDDERS.

SIMPLE HUSKING DEVICES.

One of the earliest devices used for husking corn was the husking peg. Several patterns of this are in common use. There are also other aids to corn husking made in the form of gloves, with projecting points or pegs. Equipped with such a glove the man passes along the rows, husks the ears by tearing off the husks and snapping the stems, and tosses them into the wagon which is drawn alongside. Such husking pegs and gloves are also used in husking corn from the shock.

The early colonists did not remove the husks from the ears immediately upon bringing the corn from the fields. They usually snapt the ears from the stalks without removing the husks. They held that it was better to allow the husks to remain on the ears for protection against frost and moisture. Later in the season the crops were often husked by husking parties assembled at the various farms in their respective communities during the autumn days and early evenings; and their work was always followed by some form of merrymaking, as a dance or a "play party," which often extended into the early morning hours. The corn was stored in high cribs erected at convenient points near the other farm buildings.

EARLIER MECHANICAL HUSKERS.

The first patent on a corn husker was issued in 1837. The machine comprises essentially a pair of roughened parallel rollers designed to tear off the husks. This machine represents one of the earliest attempts to utilize machinery for preparing the corn crop for the market. It assumes that the ear shall be plucked from the stalks by hand.

In 1866 a New York concern began the manufacture of a husker having a single snapping roll made of hardwood. Another roller set with stiff knives located just behind the hardwood roller, cut the stalk into short lengths. The ears of corn as they were broken off by the snapping roll fell down upon the husking rolls. These were about 2 inches in diameter and rotated toward each other. A small revolving shaft set with spikes and located directly above the line of contact of the husking rolls, caused the ears to revolve so as to present all of the husks to the action of the husking machine.

Another form of husker consisted of a snapping roll much the same as that described above, and several husking rolls whose effectiveness depended upon the action of rubber aprons. These past over each roller like belts over a pulley, and tended to draw the husks in with them. Later, about 1880, the Phillips and Jones machines added to this idea by putting on a pair of snapping rolls. These were the first really successful huskers.

COMBINED HUSKERS AND SHREDDERS.

Thus far no machine had been produced designed to perform more than one operation on the stalks, except some of the unsuccessful and later experimental harvester types designed to pick and husk the ears, as previously described. Between 1880 and 1890 a great deal of attention was given to thrashing corn. This practise so battered the stalk as to make every part of it available as a cattle food. Fodder cutters had been in use for many years, yet this method of preparing corn fodder left the fibrous part of the stalk in a tough, woody condition which the cattle did not much relish. The bruising and shredding action of the thrasher put the stalk in a more palatable form. The repeated shortages and failures of the hay crop during the decade 1880–90, together with the results of attempts at thrashing corn led to the invention of the combined husker and shredder, which takes the stalks with the ears on them, removes the ears, husks them, and prepares the stalks for feeding. A combined husker and shredder patented by J. F. Hurd, of Minnesota, in 1890, application having been filed in 1887, is one of the earliest of the shredder type.

There are at this time many different makes of this machine in the market. They are of various designs and are frequently made so as to be fitted with exchangeable cutter and shredder heads. The general construction of all machines of this class is very much the same, however. Some are rather complicated in their construction while others are very elementary. A discussion of one of the more complicated will serve to explain the general operation of all. By referring to figure 22 the construction will be easily understood.

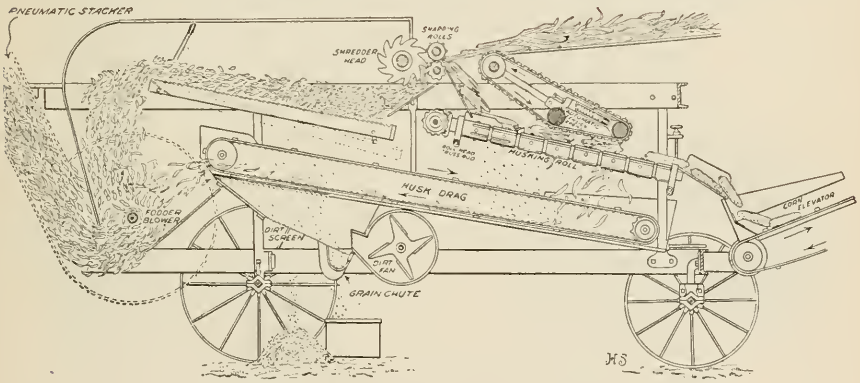


FIG. 22.—Skeleton of husker and shredder.

The stalks are first fed to the snapping rolls, where the ears are broken from them. The stalks are driven forward by the snapping rolls until they meet the shredder head, where they are cut to shreds by knives of special forms shown in figure 23. The shredded parts of the stalk fall upon a vibrating carrier whose motion is complemented by the action of arms. The shreds fall from this carrier into the blast from the fodder blower, which carries them up thru the stacker.

The ears which are broken from the stalks by the snapping rolls drop upon the husking rolls where the husks are torn from them. The husked ears gradually descend along the inclined husking rolls until they finally fall upon an elevator which carries them to the bin or other place provided for them.

The husks fall upon a conveyor chain which drags them back to the fodder blower, where they join the shreds from the stalk. The loose grain falls from the vibrating carrier and husk conveyor upon a screen. As it falls it is met by a mild blast which removes the dust from it. This grain is then collected in a trough or chute and is driven by means of a screw conveyor to one side of the machine.

This machine combines in its construction many elements used in earlier machines, both huskers and fodder cutters. The snapping rolls and husking pegs are both ideas found in machines described in preceding paragraphs, while the shredder heads are not greatly different from those of the fodder cutters of earlier design. The blower and cleaning and carrying devices are very much like those of the thrasher. Self-feeding and safety devices are now largely used as a protection against the danger of having one's hand or arm caught in the mechanism (fig. 24). Where the self-feeder is used, a revolving band cutter is commonly placed a little ahead of the snapping rolls.

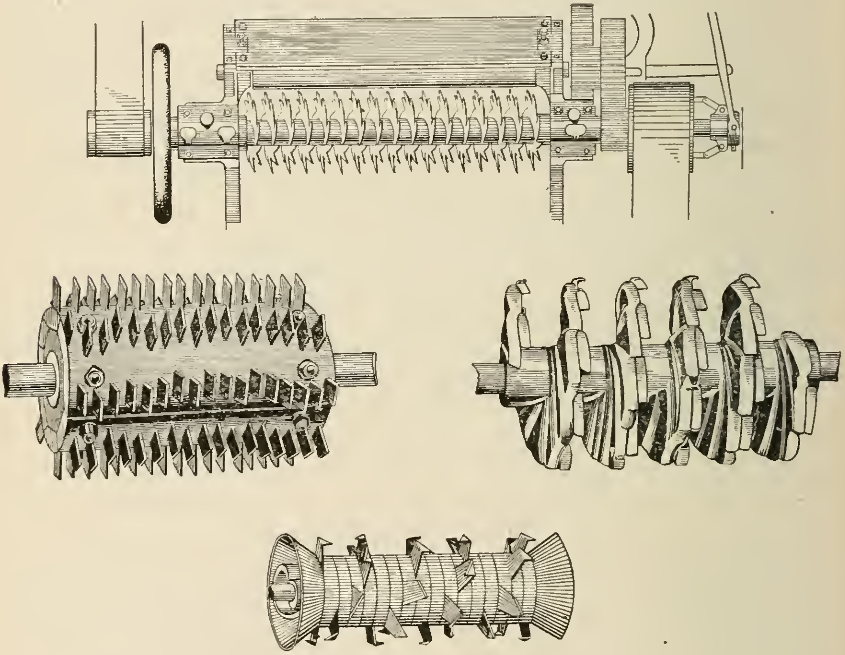
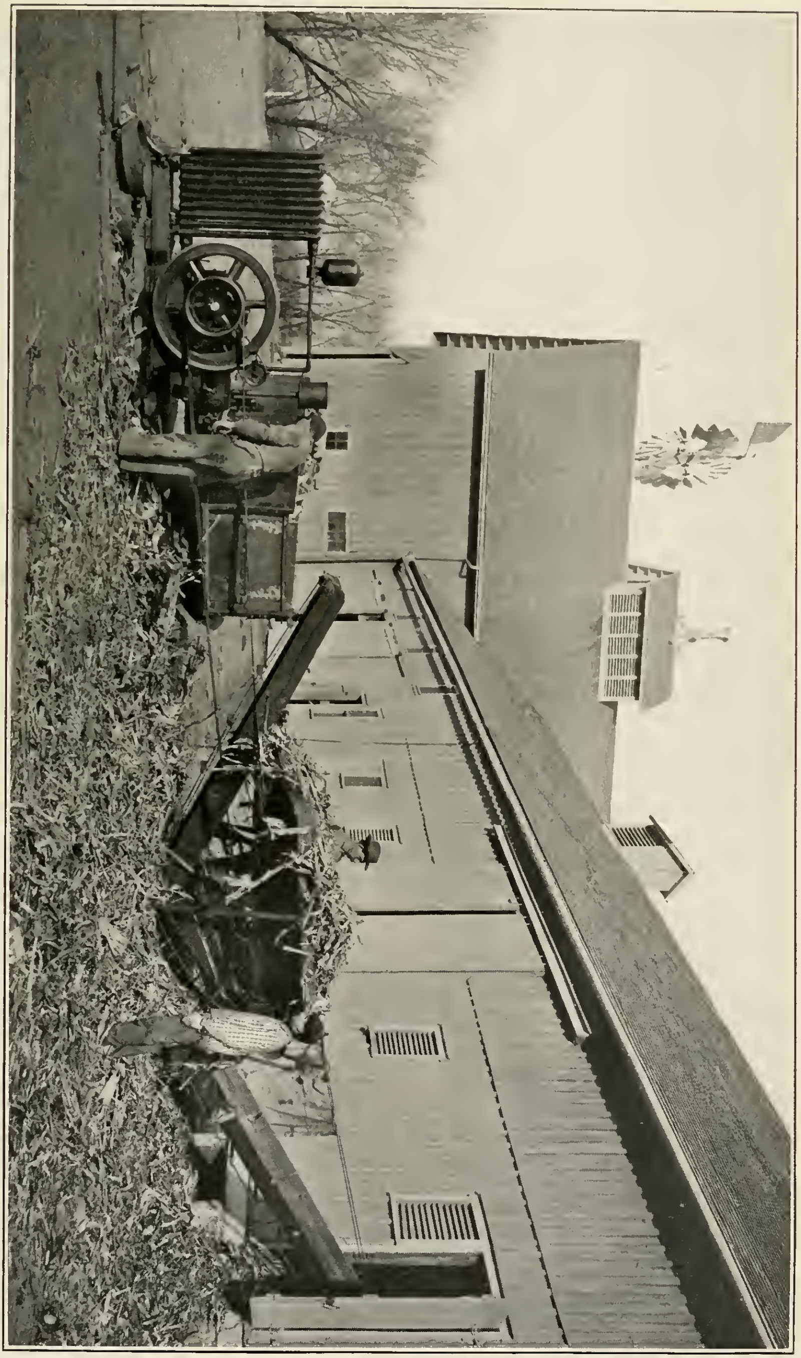


FIG. 23.—Forms of shredder heads.

The superior convenience of having the stalks bound into bundles is most evident where these machines are used. In bundles the stalks keep straight and thus avoid the delay caused by having them come to the machine in a disordered condition. There is also less danger of choking the machine. Plate IV shows a husker and shredder run by a gasoline engine.

PLATE IV.



HUSKER AND SHREDDER RUN BY GASOLINE ENGINE.

COST OF PREPARING CORN FODDER.

The cost of preparing corn fodder by the various methods and with the different machines depends upon a great many variable factors. It depends upon the yield of corn per acre, upon the method of harvesting, upon the distance the fodder is to be hauled, the size and efficiency of the working force; the size, capacity, and speed of the machine, and the motive power used.

COST OF FILLING THE SILO.

In cutting corn for ensilage we have the records kept by several experiment stations, as to cost, a few of which are here given.

An accurate record was kept of the cost of harvesting and storing 45 tons put into the silo in three days.[a] The force employed was as follows: Portable engine, power cutter, one two-mule cart with mules, one single cart with mule, one mule hauling fuel and water for engine, one foreman, one engineer and fireman, two drivers, three corn cutters, two men at cutting machine, one man packing in silo, one boy helper on water cart.

The items of cost were these: Hire of engine and engineer, three days, at $4 per day, $12; fuel, $3; teams and manual labor in all, $46.40; putting cover and weights on silo, $3; total, $64.40, or $1.43 per ton. It was estimated that the tangled condition of the corn in the field fully doubled the labor of cutting and loading it, and had the ensilage cutter been larger, the same engine and fuel could have doubled the quantity cut per day. It is easy to see how these improvements might have reduced the cost to $1 per ton for storing.

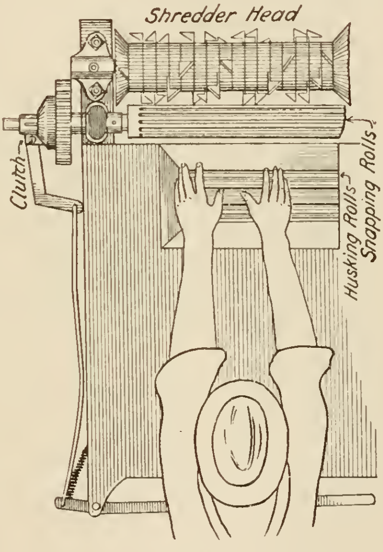


FIG. 24.—Safety device for shredder.

Cost of harvesting and filling silo.[b]

Capacity of machine, per 10-hour day	tons	50
Six men in field cutting and loading, at $1.33		$7.98
Two teams hauling, at $2		4.00
One driver, at $1.33		1.33
Two men feeding machine, at $1.33		2.66
Two men packing in silo, at $1.33		2.66
One man at engine, at $1.33		1.33
Coal used, one-fifth ton, at $8		1.60
Cost of harvesting 50 tons		21.56
Cost per ton		.43

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[a] Maryland Sta. Rpt. 1889, p. 103.

[b] Minnesota Sta. Bul. 2, p. 7.

Professor King found that the average cost of cutting and putting corn into the silo, on a number of Wisconsin farms, was 58.8 cents per ton.[a]

Professor Georgeson found that it cost 62.3 cents, 70.9 cents, and 50.8 cents for three different silos, or an average of 61.3 cents, per ton of silage put up.[b]

Mr. T. L. Allen, Kinsman, Ohio, says:

> With modern machinery and good management, corn can be put into the silo at 35 to 40 cents per ton. Indeed, with our large machinery and strong force of men we have put it in the silo for less than 30 cents.

With the larger and improved ensilage cutters having self-feeders and blowers, and the superior methods in handling the corn, it is safe to say that corn may be harvested and put into the silo in the form of silage, at an average cost of 50 cents per ton.

COST OF SHREDDED FODDER.

The cost of making the cornstalk into shredded fodder after it has been allowed to cure in the field varies in the same way as that of preparing silage. We may, however, gather some ideas of the value of the machines used for this purpose.

We have already learned the cost of cutting the corn and putting it into shocks, and also that the average cost per bushel of husking corn from the shock in the fields is 5.3 cents per bushel, or at an average of 44 bushels per acre, the cost will be $2.33 per acre. To this should be added about 35 cents per acre for hauling the ears to the crib, or a total of $2.68 per acre for husking the corn by hand, and this leaves the stover in the field. If the stalks are hauled to the feed lot it will involve an additional cost. When huskers and shredders are used for husking the corn and shredding the fodder, the farmer will have to decide the question as to what method of doing the work he desires to employ. There are machines on the market which will husk but 100 bushels per day, and there are those which will husk 1,000 bushels per day. The smaller ones are for the farmer who desires to do his own work.

With the general introduction of the gasoline engine on the farm, a small individual outfit (Pl. IV) is very desirable. With such an outfit the farmer may do his work at his convenience as he needs the corn and the fodder, and may also do some work for neighbors, which will aid in paying for the machine. It requires one man to feed; one to look after the engine, shredder, and the corn in the wagon; one man in the mow to remove the fodder, one to unload the wagons, two teams, and one loader in the field. Six gallons of gasoline will supply the fuel for a ten-hour run. The computed cost would be:

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[a] F. W. Woll, Book on Silage, p. 118.

[b] Kansas Sta. Bul. 48, p. 37.

Cost of shredding corn.

Use of engine and shredder and repairs, per day	$1.00
Five men, at $1.50 each	7.50
Two teams, at $3 each	6.00
Power, 6 gallons of gasoline, at 15 cents per gallon	.90
Total cost per day	15.40

From experiments conducted by the author with the above outfit, it was found that the number of bushels husked per hour varied considerably with conditions, but that the average was 18 bushels, or 180 bushels per day. This, at the average yield of corn per acre previously derived, would be equal to 4 acres per day. To husk 180 bushels by hand and put it in the crib would cost $10.96. This would leave a cost of $4.44 for 4 acres of corn fodder shredded and delivered in the mow. The average yield of shredded fodder is 2 tons per acre. This would give a cost of 55 cents per ton for hauling the fodder from the field, shredding it, and placing it in the barn ready to feed. When corn has been husked in the field and the farmer wishes the fodder shredded, it costs him about $1.50 per acre for shredding the fodder by machine.

With large machines the work of husking and shredding corn is usually custom work. The owner of the machine furnishes the shredder and engine, with two men, charging the farmer from 4 to 5 cents per bushel for this work. The farmer will have to furnish the fuel and the teams, as well as the balance of the help to run the machine. These large machines require from 6 to 8 teams and 20 to 25 men for full operation. The large machine, while it does the work quickly, has the disadvantage of requiring a large crew of men and teams, and if anything goes wrong with either engine or shredder, this force is idle at the expense of the farmer until the machine is repaired.

From some investigations conducted by sending out letters of inquiry from the Iowa Experiment Station to all parts of the State, the following results were obtained:

> From the entire number of reports received, the average cost of machines for shredding was $1.55 per acre; the cost of fuel was 31.4 cents; and the total cost of shredding, per acre, varied from $2.45 to $6.65. This is a wide range, but the conditions under which the shredding was done varied correspondingly according to the distance hauled, yield of stover per acre, kind and size of machine used, and work required in moving the outfit; also as to physical conditions of the fodder and accidents with machine.
>
> The average cost of shredding 1,600 acres was found to be $4.41 per acre, and this is believed to be a fair average under ordinary conditions.

The estimate of yield of corn per acre in the above case was 57.25 bushels, which is rather high even for Iowa; the yield of fodder, 2 tons per acre, and the cost of husking in the field, 5 cents per bushel. At these figures the cost of shredding the fodder would be 77 cents per ton.

SUMMARY.

The following table summarizes the data obtained as to the cost and value of corn-harvesting machines:

Summary of data regarding corn-harvesting machinery and its use.

AVERAGE DATA FOR HARVESTING BY HAND.

Cost of implement	$1.
Number of hills per shock	160.
Acres 1 man harvests per day	1.47 acres.
Cost of cutting and shocking	$0.065 per shock; $1.50 per acre.

AVERAGE DATA FOR HARVESTING WITH SLED HARVESTER.

Cost of implement	$5 to $50.
Number of hills per shock	144.
Acres 2 men and 1 horse harvest per day	4.67 acres.
Cost of cutting and shocking	$1.18 per acre.

AVERAGE DATA FOR HARVESTING WITH CORN BINDER.

Cost of implement	$125.
Life in years or acres cut	8.17 years; 669 acres.
Acres cut per day by 1 man and 3 horses	7.73 acres.
Acres shocked per day, 1 man	3.31 acres.
Cost of cutting and shocking	$1.50 per acre.

AVERAGE DATA FOR HARVESTING WITH CORN SHOCKER.

Cost of implement	$125.
Number of hills per shock	100.
Shocks or acres 1 man and 3 horses harvest per day	151 shocks; 4.67 acres.
Cost of cutting and shocking	$1.06 per acre.

Cost per bushel of picking and husking corn.

	Cents.
By hand from field	3.5
Additional cost of team for cribbing	1.0
By hand from shock	5.3
Additional cost of team for cribbing	0.79
By corn picker from field	4.1
By husker and shredder from shock	4.5

Cost per acre of husking corn and preparing fodder.

	By hand.	Sled cutter.	Binder.	Shocker.
Cutting and shocking corn	$1.50	$1.18	$1.50	$1.06
Husking out of shock by hand	2.68	2.68		
Husking and shredding by machine			4.41	4.41
Hauling and shredding fodder	2.50	2.50		
Comparative cost	6.68	6.36	5.91	5.47

Comparative returns per acre of husking corn from the field, of cutting and feeding from shock, and of cutting and shredding by the various methods.

Method employed.	Bushels per acre.	Price per bushel.	Value of corn per acre.	Cost of husking per acre.		Net value of corn.	
				By hand.	By machine.	Hand.	Machine.
Stalks left standing	44	$0.44	$19.36	$1.98	$1.80	$17.38	$17.56
Cut, and stalks fed whole	44	.44	19.36	2.68	....	16.68	....
Cut, and stalks shredded	44	.44	19.36	....	1.98	....	17.38

Method employed.	Yield of stover per acre.	Value of stover per ton.	Total value of stalks per acre.	Net value of stalks per acre.			Net value of entire crop.		
				Hand.	Large-crew machines.	Individual machines.	Hand.	Large machines.	Small machines.
	Tons.								
Stalks left standing	....	....	$0.55	....	....	....	$17.93	$17.81	....
Cut, and stalks fed whole	2	$4.00	8.00	$3.82	$3.82	$4.26	23.18	23.50	$23.62
Cut, and stalks shredded	2	6.00	12.00	5.32	6.09	7.09	24.68	25.45	26.45

The net value of the crop is found to be $17.93 for husking by hand and leaving the stalks standing in the field. This is obtained by adding to the net value of the corn 55 cents per acre for the stalks and subtracting the cost of husking by hand.

By allowing 25 cents per acre as the value of the fodder in field where corn picker is used, and adding this to the net value of the corn and subtracting $1.80 per acre for picking with the machine, we derive the net value of the crop of $17.81 for this method of harvesting, which indicates a small loss per acre as a result of using the corn picker.

The net value of the crop by feeding the stalks whole is obtained by taking the total value of the corn and fodder and subtracting the costs of cutting and husking by hand, cutting with sled harvester and husking by hand, and cutting with corn shocker and husking by hand.

The net value of the crop by utilizing the fodder in the shredded form is obtained by assuming a greater value of shredded fodder over whole cornstalks of 33 per cent, adding this value of the fodder to the value of the corn and subtracting the various costs of cutting, husking, and shredding the corn by the various hand and machine methods.

CONCLUSIONS.

The best way to preserve the greatest quantity of food materials of the original corn fodder for feeding of farm animals is by means of the corn harvester, ensilage cutter, and the silo. The cost of placing 1 acre of corn in the silo is about the same as that of an acre of cured fodder.

The farmer who would secure the full value of his corn crop should secure the fodder with as much care as he gives his clover hay, harvesting it at the proper period, and not allowing it to become ruined by rain or frost. By the use of the proper machinery for harvesting the corn crop, the farmer may increase the net income from his crop $8.72 per acre over hand methods of harvesting the ears and wasting the stalks and still allow full price for the use of the different machines.

There is a limit beyond which it is not profitable for a farmer to invest in corn-harvesting machinery, and the amount of work to be done by the machine each year should be carefully considered before a purchase is made.

○

LIST OF PUBLICATIONS OF THE OFFICE OF EXPERIMENT STATIONS ON IRRIGATION AND DRAINAGE—Continued.

Bul. 133. Report of Irrigation Investigations for 1902, under the direction of Elwood Mead, chief. Pp. 266.
Bul. 134. Storage of Water on Cache la Poudre and Big Thompson Rivers. By C. E. Tait. Pp. 100.
Bul. 140. Acquirement of Water Rights in the Arkansas Valley, Colorado. By J. S. Greene. Pp. 83.
Bul. 144. Irrigation in Northern Italy—Part I. By Elwood Mead. Pp. 100.
Bul. 145. Preparing Land for Irrigation and Methods of Applying Water. Prepared under the direction of Elwood Mead, chief. Pp. 84.
Bul. 146. Current Wheels: Their Use in Lifting Water for Irrigation. By Albert Eugene Wright. Pp. 38.
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*Bul. 148. Report on Irrigation Investigations in Humid Sections of the United States in 1903. Pp. 45.
*Bul. 157. Water Rights on Interstate Streams. By R. P. Teele and Elwood Mead. Pp. 118. (Separates only.)
Bul. 158. Report on Irrigation and Drainage Investigations, 1904. Under the direction of Elwood Mead, chief. Pp. 755. (Separates only.)
Bul. 167. Irrigation in the North Atlantic States. By Aug. J. Bowie, jr. Pp. 50.
Bul. 168. The State Engineer and His Relation to Irrigation. By R. P. Teele. Pp. 99.
Bul. 172. Irrigation in Montana. By S. Fortier. Pp. 108.

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Bul. 270. Modern Conveniences for the Farm Home. By Elmina T. Wilson. Pp. 48.

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Circ. 67. Investigations of Irrigation Practice in Oregon. By A. P. Stover. Pp. 30.

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Issued December 14, 1906.

U. S. DEPARTMENT OF AGRICULTURE.
OFFICE OF EXPERIMENT STATIONS—BULLETIN 174.
A. C. TRUE, Director.

HISTORY
OF
FARMERS' INSTITUTES
IN THE
UNITED STATES.

COMPILED BY

JOHN HAMILTON,
FARMERS' INSTITUTE SPECIALIST.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

OFFICIALS IN CHARGE OF FARMERS' INSTITUTES.

Alabama.—C. A. Cary, professor of veterinary science, Polytechnic Institute, Auburn; G. W. Carver, director Agricultural Experiment Station, Tuskegee.

Alaska.—C. C. Georgeson, Agricultural Experiment Station, Sitka.

Arizona.—R. H. Forbes, director Agricultural Experiment Station, Tucson.

Arkansas.—W. G. Vincenheller, director Agricultural Experiment Station, Fayetteville.

California.—E. J. Wickson, superintendent of Farmers' Institutes, University of California, Berkeley; D. T. Fowler, conductor of Farmers' Institutes in central and northern California, Berkeley; J. B. Neff, conductor of Farmers' Institutes in southern California, Anaheim; W. T. Clark, assistant superintendent of Farmers' Institutes, Berkeley.

Colorado.—W. L. Carlyle, dean of School of Agriculture, State Agricultural College, Fort Collins; Fred P. Johnson, assistant superintendent of Farmers' Institutes, Denver.

Connecticut.—James F. Brown, secretary State Board of Agriculture, North Stonington; J. G. Schwink, jr., secretary Connecticut Dairymen's Association, Meriden; H. C. C. Miles, secretary Connecticut Pomological Society, Milford.

Delaware.—Wesley Webb, secretary Board of Agriculture, Dover; H. Hayward, director of Agricultural Experiment Station, and superintendent of institutes for Newcastle County, Newark.

Florida.—R. W. Clothier, professor of Agriculture, University of Florida, Lake City.

Georgia.—H. C. White, president State College of Agriculture, Athens; Harvie Jordan, field agent in charge of Farmers' Institutes, 920 Empire Building, Atlanta.

Hawaii.—J. G. Smith, Agricultural Experiment Station, Honolulu.

Idaho.—H. T. French, director Agricultural Experiment Station, Moscow.

Illinois.—Frank H. Hall, secretary Illinois Farmers' Institutes, Aurora.

Indiana.—W. C. Latta, professor of Agriculture in Purdue University, Lafayette.

Iowa.—J. C. Simpson, secretary State Board of Agriculture, Des Moines.

Kansas.—J. H. Miller, superintendent of Farmers' Institutes, Manhattan.

Kentucky.—Hubert Vreeland, commissioner of Agriculture, Frankfort.

Louisiana.—Charles Schuler, commissioner of Agriculture, Baton Rouge.

Maine.—A. W. Gilman, commissioner of Agriculture, Augusta.

Maryland.—W. L. Amoss, director Farmers' Institutes, Benson.

Massachusetts.—J. L. Ellsworth, secretary State Board of Agriculture, Boston.

Michigan.—L. R. Taft, superintendent of Farmers' Institutes, Agricultural College.

Minnesota.—O. C. Gregg, director Farmers' Institutes, Lynd.

Mississippi.—E. R. Lloyd, director Farmers' Institutes, Agricultural College.

Missouri.—Geo. B. Ellis, secretary State Board of Agriculture, Columbia.

Montana.—F. B. Linfield, director Agricultural Experiment Station, Bozeman.

Nebraska.—E. A. Burnett, director Agricultural Experiment Station, Lincoln; Val Keyser, assistant superintendent of Farmers' Institutes, Station A, Lincoln.

Nevada.—J. E. Stubbs, president Nevada State University, Reno.

New Hampshire.—N. J. Bachelder, secretary State Board of Agriculture, Concord.

New Jersey.—Franklin Dye, secretary State Board of Agriculture, Trenton.

New Mexico.—John D. Tinsley, superintendent of Farmers' Institutes, Agricultural College.

New York.—F. E. Dawley, director Farmers' Institutes, Fayetteville.

North Carolina.—S. L. Patterson, commissioner of Agriculture, Raleigh; Tait Butler, professor veterinary science, College of Agriculture and Mechanic Arts, field agent, Raleigh.

North Dakota.—E. E. Kaufman, superintendent of Farmers' Institutes, Fargo.

Ohio.—T. L. Calvert, secretary State Board of Agriculture, Columbus.

Oklahoma Territory.—C. A. McNabb, secretary State Board of Agriculture, Guthrie.

Oregon.—J. Withycombe, director Agricultural Experiment Station, Corvallis.

Pennsylvania.—A. L. Martin, deputy secretary of Agriculture, Harrisburg.

Porto Rico.—D. W. May, Agricultural Experiment Station, Mayaguez.

Rhode Island.—John J. Dunn, secretary State Board of Agriculture, Providence.

South Carolina.—J. N. Harper, director Agricultural Experiment Station, Clemson College.

South Dakota.—A. E. Chamberlain, superintendent of Farmers' Institutes, Howard.

Tennessee.—W. W. Ogilvie, commissioner of Agriculture, Nashville.

Texas.—J. W. Carson, director Farmers' Institutes, College Station.

Utah.—P. A. Yoder, director Agricultural Experiment Station, Logan.

Vermont.—George Aitken, secretary State Board of Agriculture, Woodstock.

Virginia.—G. W. Koiner, commissioner of Agriculture, Richmond; A. M. Soule, director Agricultural Experiment Station and secretary Virginia State Farmers' Institute, Blacksburg.

Washington.—E. A. Bryan, president Agricultural College and School of Science, Pullman; E. E. Elliott, professor of Agriculture, Washington Agricultural College, field agent, Pullman.

West Virginia.—H. E. Williams, superintendent of Farmers' Institutes, Sunlight.

Wisconsin.—G. B. McKerrow, director Farmers' Institutes, Madison.

Wyoming.—B. C. Buffum, director Agricultural Experiment Station, Laramie.

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934. Issued December 14, 1906.

U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN 174.

A. C. TRUE, Director.

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HISTORY
OF
FARMERS' INSTITUTES
IN THE
UNITED STATES.

COMPILED BY

JOHN HAMILTON,
FARMERS' INSTITUTE SPECIALIST.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

THE OFFICE OF EXPERIMENT STATIONS.

STAFF.

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E. W. Allen, Ph. D., *Assistant Director and Editor of Experiment Station Record.*
W. H. Beal, B. A., M. E., *Chief of Editorial Division.*
John Hamilton, B. S., M. S. A., *Farmers' Institute Specialist.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., October 15, 1906.

Sir: I have the honor to transmit herewith a History of Farmers' Institutes in the United States, compiled by John Hamilton, Farmers' Institute Specialist of this Office.

This bulletin gathers together such data respecting the origin and progress of the farmers' institute movement in the several States and Territories as it has been found possible to secure, and presents the material in an abridged form for the information of institute workers. It brings the history of the institutes up to the year 1904, the subsequent history of the institutes being recorded in the annual reports of the Farmers' Institute Specialist of the Department. I recommend its publication as Bulletin 174 of this Office.

Respectfully,

A. C. True, *Director.*

Hon. James Wilson,
Secretary of Agriculture.

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HISTORY OF FARMERS' INSTITUTES IN THE UNITED STATES.[a]

INTRODUCTION.

The farmers' institute movement in the United States has now reached a degree of importance and development that places it alongside of the leading institutions of the country organized in the interest of industrial education. Forty-five States and Territories held institutes in 1905, aggregating 10,555 half-day sessions, which were attended by 995,192 persons, chiefly adults.

The teaching force in the employ of the State directors numbered 995. The personal history of 791 of these lecturers shows that 386 hold college degrees, 159 had taken partial college courses, 130 had normal or high-school certificates, and 116 had common-school training. In addition to this force, the local managers of the several counties in 28 States reporting employed 3,331 local lecturers who read papers or delivered addresses in the institute meetings.

The appropriations for institute purposes by the several States in 1905 amounted to $225,738.89. This development has taken place within about thirty years, and the greater part of it within the past fifteen years.

The marvelous growth of this form of agricultural instruction in so short a period is accounted for by the fact that about the time that this movement began agricultural lands in many States were beginning to show the injurious effects of constant cropping without restoration of the fertilizing elements thus abstracted, and the majority of their owners were coming to realize that the restoration of their lands to profitable production was a problem for the solution of which they needed the assistance of experts who had made special study of this subject.

Meetings were called by the farmers of the various communities for conference and interchange of opinion respecting the difficulties that they were encountering. To these meetings successful farmers were invited and given opportunity to explain the methods by which they had succeeded. Later, as the agricultural experiment stations were developed, expert scientists from these stations and professors from the agricultural colleges were brought in to announce the late discoveries of science as these discoveries related to agriculture, and to give advice as to new methods that might be introduced with prospect of success.

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[a] Additional publications on this subject: Annals of Horticulture, 1891, p. 137, ff.; Ann. Rpt. Penn. Dept. Agr. 1895, p. 97, ff.; U. S. Dept. Agr., Experiment Station Record, vol. 7, p. 635, ff.; U. S. Dept. Agr., Office of Experiment Stations Bul. 79.

The feeling of need for information respecting their calling was so general among the farmers and the instruction which these experts imparted was so helpful that in all of the States the demand for such instruction became urgent. In response to this demand the legislatures in most of the States provided for the organization and support of farmers' institutes. The indications are that the institute has come to stay and that out of the early and cruder forms there will gradually be developed a system that will be thoroly organized for giving systematic instruction in agriculture and become recognized as a necessary part of the general system of industrial education.

If the development referred to should be realized, it will become of interest to students of industrial education in future years to know precisely how the movement originated in the several States and understand the circumstances that surrounded it and the forces that aided in its progress. With this in mind, as well as in the belief that institute workers even now will be interested in the facts presented, the Institute Specialist of the Office of Experiment Stations of the Department of Agriculture has collected such data as could be had respecting the origin and early history of the institutes in the several States. It was felt that it was important to do this while there are still living those who were identified with the movement from its beginning and are consequently familiar with it in all of its details.

A letter was sent out to the institute directors of the several States and Territories in April, 1904, stating that it was proposed to publish in bulletin form a history of the farmers' institutes in the United States, partly as a matter of general interest, but specially that an authentic record may be had which can be used for reference and asking each director to prepare a brief paper giving an account of the origin and development of the farmers' institute movement in his State.

In response to this letter the majority of the State directors prepared statements more or less complete and sent them in to the Institute Specialist. In a number of instances the preparation of the history was delegated by the director to some citizen known to be familiar with the facts, who collected the data and transmitted the manuscript to this Office.

In some cases bare outlines or disconnected facts were given; in others a large amount of irrelevant material was included in the statements, and in still others the accounts far exceeded the limits of space which could be allowed. It became necessary, therefore, in editing the copy to rewrite entirely a number of the histories, to rearrange the facts in others so as to present them in consecutive order, and in others to cut out superfluous matter. In no case, however, has anything been omitted that was regarded as essential to a proper understanding of the history, and no statement has been inserted that was not justified by some authoritative record.

No attempt has been made to summarize the several histories or to comment upon the work that each State has done. The purpose has been to present the facts as they have been furnished by competent authorities and leave the drawing of inferences and conclusions to those who study and compare them.

This bulletin brings the history of the institutes up to about the time of the appointment of the Farmers' Institute Specialist of this Office in 1903. The subsequent history of the institutes will be found quite fully recorded in the annual reports of the Institute Specialist published in the annual reports of the Office of Experiment Stations.

It is hoped that the information furnished by this history may not only preserve a record of the facts, but may also encourage and aid those who are interested in the future development of the institute work by exhibiting its progress in the past.

HISTORIANS.

The following persons prepared histories or supplied data for their respective States and Territories, and the valuable service that each has rendered is hereby acknowledged:

Alabama.—C. A. Cary, professor of veterinary science in Alabama Polytechnic Institute, Auburn.

Alaska.—No institutes.

Arizona.—R. H. Forbes, director Agricultural Experiment Station, Tucson.

Arkansas.—No institutes.

California.—E. J. Wickson, professor of practical agriculture, University of California, Berkeley.

Colorado.—A. C. True and F. H. Hall, in article in Experiment Station Record, Vol. VII, page 638, and L. H. Bailey in U. S. Department of Agriculture, Office of Experiment Stations Bul. 79, page 10.

Connecticut.—T. S. Gold, ex-secretary-State Board of Agriculture, West Cornwall.

Delaware.—Wesley Webb, director Farmers' Institutes, Dover.

Florida.—Charles M. Conner, superintendent Farmers' Institutes, Lake City.

Georgia.—Harvie Jordan, superintendent Farmers' Institutes, Monticello.

Hawaii.—Jared G. Smith, Agricultural Experiment Station, Honolulu.

Idaho.—H. T. French, director Agricultural Experiment Station, Moscow.

Illinois.—A. B. Hostetter, secretary Illinois Farmers' Institutes, Springfield.

Indiana.—W. C. Latta, superintendent Farmers' Institutes, Lafayette.

Indian Territory.—No institutes.

Iowa.—John R. Sage, United States Climatic and Crop Service, Des Moines.

Kansas.—J. T. Willard, director Agricultural Experiment Station, Manhattan.

Kentucky.—Hubert Vreeland, commissioner of agriculture, Frankfort.

Louisiana.—J. G. Lee, commissioner of agriculture and irrigation, Baton Rouge.

Maine.—A. W. Gilman, commissioner of agriculture, Augusta.

Maryland.—W. L. Amoss, superintendent of Farmers' Institutes, College Park.

Massachusetts.—Howard N. Legate, clerk State Board of Agriculture, Boston.

Michigan.—L. R. Taft, superintendent of Farmers' Institutes, Agricultural College.

Minnesota.—Thomas Shaw, editor of "The Farmer," St. Anthony Park.

Mississippi.—W. L. Hutchinson, director Agricultural Experiment Station, Agricultural College.

Missouri.—George B. Ellis, secretary State Board of Agriculture, Columbia.
Montana.—F. B. Linfield, director Agricultural Experiment Station, Bozeman.
Nebraska.—E. A. Burnett, director Agricultural Experiment Station, Lincoln.
Nevada.—J. E. Stubbs, director Agricultural Experiment Station, Reno
New Hampshire.—N. J. Bachelder, secretary State Board of Agriculture, Concord.
New Jersey.—Franklin Dye, secretary State Board of Agriculture, Trenton.
New Mexico.—J. D. Tinsley, vice-director Agricultural Experiment Station, Mesilla Park.
New York.—Miss K. B. Allis, Office of Farmers' Institutes, Fayetteville.
North Carolina.—W. F. Massey, horticulturist, Agricultural Experiment Station, Raleigh.
North Dakota.—E. E. Kaufman, director Farmers' Institutes, Bismarck.
Ohio.—W. W. Miller, secretary State Board of Agriculture, Columbus.
Oklahoma.—J. B. Thoburn, secretary State Board of Agriculture, Guthrie.
Oregon.—James Withycombe, director Agricultural Experiment Station, Corvallis.
Pennsylvania.—A. L. Martin, deputy secretary of agriculture, Harrisburg.
Porto Rico.—No institutes.
Rhode Island.—William Williams, member State Board of Agriculture, Bristol.
South Carolina.—J. S. Newman, superintendent of Farmers' Institutes, Clemson College.
South Dakota.—S. A. Cochran, irrigation engineer, Brookings; James H. Shepard, professor of chemistry, Agricultural College, Brookings.
Tennessee.—W. W. Ogilvie, commissioner of agriculture, Nashville.
Texas.—J. H. Connell, editor, "Farm and Ranch," Dallas,
Utah.—John A. Widtsoe, director Agricultural Experiment Station, Logan.
Vermont.—George Aitken, secretary State Board of Agriculture, Woodstock.
Virginia.—G. W. Koiner, commissioner of agriculture, Richmond; A. M. Soule, director Agricultural Experiment Station, Blacksburg.
Washington.—E. A. Bryan, president Washington Agricultural College, Pullman.
West Virginia.—J. B. Garvin, director Farmers' Institutes, Charleston; A. D. Hopkins, Division of Entomology, Washington, D. C.
Wisconsin.—George McKerrow, superintendent Farmers' Institutes, Madison.
Wyoming.—B. C. Buffum, director Agricultural Experiment Station, Laramie.

GOVERNMENT AID TO INSTITUTES.

The United States Department of Agriculture has undertaken to assist the States in their institute work. At the request of the Secretary of Agriculture, the Fifty-seventh Congress provided for the appointment of a Farmers' Institute Specialist in the Office of Experiment Stations of the Department, and appropriated $5,000 for meeting the necessary expenses of the new office.

The duties of this officer, as stated in the act making the appropriation, are "To investigate and report upon the organization and progress of farmers' institutes in the several States and Territories, and upon similar organizations in foreign countries, with special suggestions of plans and methods for making such organizations more effective for the dissemination of the results of the work of the Department of Agriculture and the experiment stations, and of improved methods of agricultural practice."

In anticipation of the action of Congress the United States Civil Service Commission, July 23, 1902, issued a circular letter to the effect that an examination would be held September 1, 1902, for the position of Farmers' Institute Specialist in the Office of Experiment Stations of the Department of Agriculture, the examination to be open to all citizens of the United States who comply with the requirements as set forth in the forms of examination which the Commission prescribed.

From the eligible list thus secured the Secretary of Agriculture, Hon. James Wilson, under date of February 9, 1903, tendered the position to John Hamilton, of State College, Pa., then secretary of agriculture of the State of Pennsylvania. Mr. Hamilton accepted the position and assumed the duties of the office April 1, 1903.

Since that date the office has collected and published the laws under which institutes are held in the several States and Territories; a list of names of lecturers in the employ of the State directors with their post-office addresses; bulletin on Agricultural Instruction for Adults in the British Empire; bulletin on Agricultural Instruction for Adults in Continental Countries; Proceedings of the Ninth and Tenth Annual Meetings of the American Association of Farmers' Institute Workers; annual reports and statistics of the farmers' institute work in the United States for the years 1903, 1904, and 1905. The Institute Specialist has had prepared syllabi of six illustrated lectures—No. 1 on the Care of Milk; No. 2, Potato Diseases and their Treatment; No. 3, Acid Soils; No. 4, Profitable Cattle Feeding; No. 5, Silage and Silo Construction, and No. 6, Essentials of Field Experimentation. There has also been prepared and published a course of study consisting of fourteen lectures on cheese-making adapted to movable schools of agriculture, and arrangements have been made for the preparation of five other courses of similar character. There is also in course of preparation a set of charts on the selection of cattle for feeding.

Arrangements have been made with the directors of the agricultural experiment stations for supplying station bulletins to the State institute lecturers and with the Division of Publications of the Department of Agriculture for sending its publications to institute workers upon application made to the Institute Specialist. A card list of the names and addresses of over 4,000 institute workers has been formed in the institute office, correspondence conducted with these persons, and literature and information supplied.

The Institute Specialist has during this period visited most of the States east of the Rocky Mountains and has conferred with institute directors and lecturers and delivered lectures in all of the States visited.

The office of the specialist has been in addition to its investigation character a clearing house for the farmers' institute workers of the country.

THE AMERICAN ASSOCIATION OF FARMERS' INSTITUTE WORKERS.

The organization of the American Association of Farmers' Institute Workers took place at Watertown, Wis., March 13, 1896. George McKerrow, of Madison, Wis., superintendent of farmers' institutes for that State, issued a call in the winter of 1896 for a meeting of the farmers' institute workers of the United States and Canada to be held at Watertown, Wis., March 13, 1896.

The attendance at this first meeting was quite small, only a few of the States being represented, and those were for the most part the nearby States. O. C. Gregg, farmers' institute superintendent for Minnesota, was elected temporary chairman, and F. W. Taylor, institute superintendent for Nebraska, was made temporary secretary.

Mr. McKerrow, in explaining the purpose of the meeting, stated that "there was felt to be a need for a meeting of the farmers' institute workers of the several States to exchange views and compare experiences. No two States have the same plan under which institute work is carried on, but all have some good points about which we all ought to be informed. There seemed to be a feeling that we should come together and acknowledge our mistakes and tell of our successes in order that others need not experience the same failures."

After discussion it was agreed to form a permanent organization, and the temporary officers, on motion of Kenyon L. Butterfield, of Michigan, were made permanent, and a committee consisting of C. W. Garfield, of Michigan; George McKerrow, of Wisconsin, and F. W. Taylor, of Nebraska, was appointed by the chair to prepare and report a constitution. The committee before adjournment reported a draft of a proposed constitution, which after discussion and amendment was adopted, the understanding being that its final ratification would take place at the next meeting of the association.

The following resolution, introduced by Mr. Garfield and adopted by the association, is worthy of special notice because of its pronounced declaration upon the question of the relation of the farmers' institute to the agricultural college and the experiment station.

Resolved, As the sense of this association, that the farmers' institutes of each State and Province should be guided by some central authority which recognizes the agricultural college and experiment station as the leaders of our system of agricultural education, and the farmers' institute as a strong, active, and effective ally.

After a very full and instructive discussion of the several subjects presented, adjournment was taken to meet in Chicago on October 14, 1896. There were present at this meeting at Watertown about thirty representative men from Wisconsin, and also delegates from Illinois, Minnesota, Ohio, Michigan, and Nebraska.

CHICAGO MEETING.

The adjourned meeting of the association was held in Chicago, according to appointment, October 14, 1896, and continued for two days. A program had been prepared for this meeting, the several subjects to be opened with addresses or papers by the following gentlemen: K. L. Butterfield, Michigan; W. C. Latta, Indiana; John Hamilton, Pennsylvania; G. A. Smith, New York; B. W. McKeen, Maine; H. C. Gregg, Minnesota; George McKerrow, Wisconsin; Mary A. Mayo, Michigan; Charles P. Fox, Idaho; W. S. Devol, Arizona; E. J. Wickson, California; R. E. A. Leach, Canada; W. W. Miller, Ohio; O. Clute, Florida, and others.

There were present at the first session 29 persons. A committee on nominations appointed by the chair recommended as officers for the ensuing year, for president, George McKerrow, of Wisconsin; vice-president, K. L. Butterfield, of Michigan; secretary and treasurer, F. W. Taylor, of Nebraska. The recommendation of the committee was unanimously adopted.

The committee that had been appointed on constitution and by-laws reported, recommending the form that had been agreed upon at the Watertown meeting. After the reading of the report John Hamilton, of Pennsylvania, offered a substitute, which, after discussion, was adopted. The substitute is as follows:

Constitution, as Adopted.

Article I. *Name.*—This organization shall be known by the name of The American Association of Farmers' Institute Managers.

Article II. *Officers.*—The officers shall consist of a president, vice-president, and secretary-treasurer, to be elected by ballot.

Article III. *Membership.*—The membership shall consist of one representative for each State or Province in the United States or Canada, who shall be in charge of the State or provincial farmers' institute work as its general superintendent, director, or manager, or his official representative.

Article IV. *Dues.*—In order to membership in this association each individual entitled to membership and qualified as stated in Article III shall pay annually to the treasurer of the association the sum of $10.

Article V. *Term of office.*—The term of office of the officers of this association shall be for one year from the 1st day of January next following their election or until their successors are elected.

Article VI. *The duties of officers.*—The duties of the officers of this association shall be those usually performed by officials of like rank in similar associations.

Article VII. *Associate members.*—Associate members of this organization may be elected from time to time upon the presentation of their names by some member of the association and upon their receiving the votes of at least two-thirds of the members present.

Article VIII. *Dues of associate members.*—The annual dues of an associate member shall be $1.

Article IX. *Power of associate members.*—Associate members shall be entitled to sit in all of the sessions of the association and to take part in all discussions, but shall have no vote.

Article X. *By-laws.* This association shall have power to make by-laws from time to time not inconsistent with this constitution.

ARTICLE XI. *Executive committee.*—There shall be an executive committee consisting of the president and the secretary-treasurer of this association, ex officio, and three other members to be elected annually by ballot, who shall meet at the call of the president and have charge of such matters of business relating to the association as it shall be necessary to attend to in the interval between the annual meetings, and it shall be their duty to report such action as they may take to the next regular meeting of the association.

ARTICLE XII. *Change in constitution.*—This constitution shall not be changed except by a vote of two-thirds of the members at a regular annual meeting held one year from the date on which the proposed alteration or amendment has been first presented.

BY-LAWS.

1. The time of meeting of this organization shall be fixt by the association.
2. Order of business:
    1. Calling the roll of membership.
    2. Reading of minutes of previous meeting.
    3. Admission of new members.
    4. Reports of committees.
    5. Election of officers.
    6. Appointment of committees.
    7. Unfinished business.
    8. New business.
    9. Adjournment.

After the adoption of the constitution and under its provision the three additional members of the executive committee were elected, as follows: John Hamilton, of Pennsylvania; W. W. Miller, of Ohio, and W. C. Latta, of Indiana. Before adjournment the place of the next meeting was fixt for Columbus, Ohio, and the time October, 1897, the exact date to be set by the executive committee.

The following list includes the names of those present at both the Watertown and Chicago meetings, as presented in the consolidated report of the proceedings of these meetings published by the secretary: [a]

Members.—J. F. Culver, Montgomery, Ala.; O. Clute, Lake City, Fla.; W. C. Latta, Lafayette, Ind.; B. Walker McKeen, Augusta, Me.; R. E. A. Leach, Brandon, Manitoba; W. L. Amoss, College Park, Md.; K. L. Butterfield, Agricultural College, Mich.; F. W. Taylor, Lincoln, Nebr.; F. E. Dawley, Albany, N. Y.; W. W. Miller, Columbus, Ohio; F. W. Hodson, Guelph, Ontario; John Hamilton, Harrisburg, Pa.; George McKerrow, Madison, Wis.

Associate members.—M. T. Allen, Waupaca, Wis.; S. C. Bassett, Gibbon, Nebr.; W. C. Bradley, Hudson, Wis.; I. H. Butterfield, Agricultural College, Mich.; W. L. Carlyle, 86 Lyndale avenue, Minneapolis, Minn.; A. F. Coddington, Syracuse, Nebr.; John W. Decker, Madison, Wis.; A. Allen Francis, New Lenox, Ill.; R. W. Furnas, Brownville, Nebr.; E. L. Furness, Furnessville, Ohio; C. W. Garfield, Grand Rapids, Mich.; Milton George, editor Farmers' Union, Chicago, Ill.; S. G. Gist, Wellsburg, W. Va.; A. P. Grout, Winchester, Ill.; W. R. Hostetter, Mount Carroll, Ill.; W. B. Lloyd, agricultural editor Farm, Field, and Fireside, Chicago, Ill.; Ed. McIntyre, Seward, Nebr.; G. A. Marshall, Arlington, Nebr.; J. H. Monrad, Winnetka, Ill.; C. J. Monroe, South Haven, Mich.; F. S. Phoenix, Bloomington, Ill.; W. A. Poynter, Albion, Nebr.; C. A. Shamel, managing editor Orange Judd Farmer, Chicago, Ill.; John L. Shawver, Bellefontaine, Ohio; John T. Stimson, Fayetteville, Ark.; B. R. Stouffer, Bellevue, Nebr.; H. F. Thurston, editor Farmers' Review, Chicago, Ill.; O. J. Vine, Canton, Ill.; W. G. Vincenheller, Little Rock, Ark.; C. J. Warner, Waverly, Nebr.; L. L. Young, Oakland, Nebr.

COLUMBUS MEETING.

The second annual convention of the association was held in Columbus, Ohio, October 27 and 28, 1897. A formal program had been prepared, and speakers had been engaged to discuss the subjects assigned. Reports from the delegates representing the several States were presented and discust. The officers elected were: President, John Hamilton, of Pennsylvania; vice-president, W. C. Latta, of Indiana; secretary-treasurer, F. W. Taylor, of Nebraska. The three elective members of the executive committee chosen were W. W. Miller, Ohio; K. L. Butterfield, Michigan, and O. C. Gregg, Minnesota.

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[a] Report of the meetings of The American Association of Farmers' Institute Managers, by F. W. Taylor, Lincoln, Nebr., 1897.

Fourteen States and two of the Provinces of Canada were represented at this meeting by their State or provincial institute directors.

It was at this meeting that action was first taken looking toward cooperation between the institutes and the National Department of Agriculture at Washington. The subject was introduced by the following question presented for discussion by the committee in charge of the question box: "What support should farmers' institutes have from the United States Department of Agriculture, and how shall such cooperation be secured?"

After very full discussion the following motion, offered by F. W. Taylor, of Nebraska, and seconded by W. L. Amoss, of Maryland, was adopted:

> Moved that the association at this time appoint a committee of three, consisting of the president-elect (John Hamilton) and two others to be appointed by the president-elect, the business of which committee shall be between the present time and the date of our next annual meeting to gather such facts as are obtainable and get in touch with the Department of Agriculture at Washington, and inquire thoroly into the question of the feasibility and advisability of a relation and union, such as has been outlined either directly or indirectly with the Agricultural Department of the United States, and submit their report at the next meeting.

The committee above referred to was duly appointed, and consisted of the president, John Hamilton, W. C. Latta, and F. W. Taylor.

The association adjourned to meet at Omaha, Nebr., in 1898, the precise date to be fixt by the executive committee. A report of the proceedings was prepared and published by the secretary.

OMAHA MEETING.

The third annual meeting of the association was held October 4 and 5, 1898, at Omaha, Nebr. The attendance was quite small, believed to have been occasioned by the fact that the association as then organized, being substantially a close corporation, was too limited in its membership to be of general interest. In the absence of the president and the vice-president, Franklin Dye, of New Jersey, was elected to preside. The following officers were elected for the ensuing year: President, Franklin Dye, of New Jersey; vice-president, F. E. Dawley, of New York; and secretary and treasurer, George McKerrow, of Wisconsin.

The committee that had been appointed at the Columbus meeting to consider the question of the cooperation of the United States Department of Agriculture with the farmers' institutes forwarded their report to the secretary of the association. The chairman of the committee and Mr. Latta were unable to be present at the meeting. As a consequence the resolutions do not seem to have been presented, or if they were no action is recorded respecting them. The report, however, had been carefully considered by the committee and would have been urged upon the attention of the association if a majority of the members had been present. The report is as follows:

> The committee appointed at the annual meeting of the American Association of Farmers' Institute Managers, held at Columbus, Ohio, October 27 and 28, 1897, to report upon "The feasibility and desirability of a more intimate relation and union between this association and the Department of Agriculture of the United States" respectfully report that after having conferred with the Hon. James Wilson, Secretary of the Department of Agriculture of the United States, they have agreed upon the following recommendations:
>
> (1) That the Secretary of the Department of Agriculture at Washington be requested to arrange for a division in connection with that Department, to be known as the "Division of Farmers' Institutes," and to appoint a suitable officer who shall be in charge.
>
> (2) That the Secretary of the Department of Agriculture be requested to arrange for the sending out of suitable scientific lecturers to the several States to assist the State managers in the farmers' institute work.

(3) That the Secretary of the Department of Agriculture, thru the officer of the Division of Farmers' Institutes, be requested to annually collect, compile, and publish statistics of the institute work conducted by the several States, and distribute such documents in the same manner as like publications are now distributed by that Department.

(4) That a bill be prepared to be presented to the Congress of the United States providing for an appropriation to the several States for farmers' institute purposes, to be apportioned pro rata, according to the number of farms (farmers) in each State.

(5) That this bill shall provide that the moneys so appropriated shall be used exclusively in the payment of the salaries and expenses of competent instructors, and that each State receiving the benefits of this act shall appropriate out of the State treasury for institute purposes at least as much as is received from the National Government.

(6) That each State before receiving the benefits of this act shall appoint a State director of institutes, who shall have charge of the expenditure of these funds, and who shall report annually on the 30th day of June to the auditor-general of his State, and also to the Secretary of the Department of Agriculture at Washington, giving an itemized account of the expenditures for institute purposes for the preceding year, according to a form to be provided by the Secretary of the Department of Agriculture at Washington.

Respectfully submitted.

John Hamilton,
W. C. Latta,
F. W. Taylor,
Committee.

The committee had agreed upon all of the items contained in the report except the portion embraced by section 6, which one of the members felt should be modified so as to permit the States to place the supervision with the agricultural college and experiment station if desired.

The association adjourned to meet in the State of New York. No formal report of the Omaha meeting seems ever to have been published.

ROCHESTER MEETING.

The fourth annual meeting of the association was held at Rochester, N. Y., March 29 and 30, 1899, and was well attended.

At this meeting the name of the association was changed from the American Association of Farmers' Institute Managers to that of the American Association of Farmers' Institute Workers. The officers elected for the ensuing year were: President, F. E. Dawley, Fayetteville, N. Y.; vice-president, Kenyon L. Butterfield, Agricultural College, Mich.; secretary-treasurer, F. W. Taylor, Lincoln, Nebr.; executive committee, F. W. Hodson, Guelph, Ontario, W. C. Latta, Lafayette, Ind., and H. W. Collingwood, New York. The proceedings of the meeting were published in the Transactions of the New York Agricultural Society and Bureau of Farmers' Institutes for 1898.

DELEVAN MEETING.

The fifth annual meeting of the association was held at Delevan, Wis., during the evening of March 15, 1900. In the absence of the president, F. E. Dawley, of New York, the chair was occupied by Clinton D. Smith, of Michigan.

The nominating committee presented the names of the following gentlemen for officers for the ensuing year: President, C. D. Smith, Lansing, Mich.; vice-president, G. A. Willmarth, Seneca, Ill., and secretary-treasurer, G. C. Creelman, Toronto, Canada. For the executive committee: W. C. Latta, Lafayette, Ind.; S. A. Cochrane, Brookings, S. Dak., and W. L. Amoss, College Park, Md. The fixing of the time and place for the next meeting was left to the executive committee. A brief account giving the minutes of this meeting was published in the annual publication of the Wisconsin Farmers' Institute for the year 1900.

BUFFALO MEETING.

The sixth annual meeting was held in Buffalo, N. Y., September 18 and 19, 1901. The officers elected at this meeting were: President, W. L. Amoss, College Park, Md.; vice-president, W. L. Hutchinson, Agricultural College, Miss., and secretary-treasurer, G. C. Creelman, Guelph, Ontario.

Up to this time the proceedings of the annual meetings were published either by the association itself or by the superintendent of institutes of the State in which the annual meeting was held. The meeting at Buffalo, however, marked an important change in this respect. The records of this meeting were reported, edited, and published by the Office of Experiment Stations of the United States Department of Agriculture, in conjunction with the secretary of the association, and were printed by the Department.[a] The proceedings of all subsequent annual meetings have been similarly reported and published.[b]

At this meeting also A. C. True, of the Office of Experiment Stations of the National Department of Agriculture, made an address that marks the beginning of the cooperation between that Department and the institutes so much desired by the institute workers. In the course of his remarks he stated that "it is the intention of Secretary Wilson in his forthcoming report to urge that an appropriation be made at the next session of Congress for work in connection with the farmers' institutes."

This meeting, although held during the period of the Exposition when President McKinley's body was awaiting burial, was well attended and the interest was maintained until the close.

WASHINGTON MEETING.

The seventh annual meeting was held in Washington, D. C., June 24–26, 1902. Inasmuch as the proceedings of this meeting of the association and those subsequently held are printed by the Department of Agriculture and are accessible upon application to that Department, it is unnecessary to do more than to mention the list of officers and the places and dates of the meeting.

The officers elected at Washington were: President, W. C. Latta, of Indiana; vice-president, J. G. Lee, of Louisiana, and secretary-treasurer, G. C. Creelman, Ontario.

TORONTO MEETING.

The eighth annual meeting was held in the Parliament Buildings, Toronto, Canada, June 23–26, 1903.

The officers elected were: President, B. W. Kilgore, Raleigh, N. C.; vice-president, E. E. Kaufman, Fargo, N. Dak.; and secretary-treasurer, G. C. Creelman, Toronto, Canada.

The attendance at this meeting was quite remarkable and the interest greater, perhaps, than at any previous meeting in the history of the organization.

ST. LOUIS MEETING.

The ninth annual meeting was held in the Agricultural Building, World's Fair Grounds, St. Louis, Mo., October 18–20, 1904.

The officers elected were: President, J. C. Hardy, Agricultural College, Miss.; vice-president, E. A. Burnett, Lincoln, Nebr.; and secretary-treasurer, G. C. Creelman, Guelph, Canada; executive committee, J. G. Lee, Baton Rouge, La.; F. H. Hall, Aurora, Ill., and L. A. Clinton, Storrs, Conn.

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 110.

[b] U. S. Dept. Agr., Office of Experiment Stations Buls. 130, 138, 154, and 165.

Full information respecting the proceedings can be had from the account published by the Department of Agriculture. This meeting had an attendance of about one hundred and is remarkable for the interest displayed and the faithfulness with which the delegates attended the several sessions.

From the time that the original constitution was adopted in 1896 there have been numerous amendments added, resulting in practically a new constitution. The changes have affected the membership of the organization by liberalizing the requirements so as to include all farmers' institute workers, whether directly connected with the State management or not.

The amended constitution is as follows:

CONSTITUTION OF THE ASSOCIATION.

Article I.

NAME.

This organization shall be known by the name of The American Association of Farmers' Institute Workers.

Article II.

OFFICERS.

The officers shall consist of a president, vice-president, and secretary-treasurer, to be elected by ballot.

Article III.

MEMBERSHIP.

Any active worker in the farmers' institutes in the United States and Canada may become a regular member of this association on payment of the annual dues, and is entitled to one vote. A delegate member representing the State farmers' institute organization shall be admitted from each State and Province, on compliance with the by-laws, and shall be entitled to cast five votes on any question: *Provided*, That the annual membership dues of the person shall be $1 and that of the State $5. Also the United States Department of Agriculture and the Office of Experiment Stations of that Department shall each be entitled to representation in the association, with the full privileges of delegate membership.

Article IV.

DUES.

The annual dues of delegate members shall be $5 for six representatives of each State. The annual dues of members not delegates shall be $1.

Article V.

TERM OF OFFICE.

The term of office of the officers of this association shall be for one year from the 1st day of January next following their election, or until their successors are elected.

Article VI.

DUTIES OF OFFICERS.

The duties of the officers of this association shall be those usually performed by officials of like rank in similar associations.

Article VII.

ASSOCIATE MEMBERS.

Honorary members of this organization may be elected from time to time upon the presentation of their names by some member of the association and upon their receiving the votes of at least two-thirds of the members present.

ARTICLE VIII.

POWER OF HONORARY MEMBERS.

Honorary members shall be entitled to sit in all of the sessions of the association and to take part in all discussions, but shall have no vote.

ARTICLE IX.

BY-LAWS.

This association shall have power to make by-laws from time to time not inconsistent with this constitution.

ARTICLE X.

EXECUTIVE COMMITTEE.

There shall be an executive committee consisting of the president and the secretary-treasurer of this association, ex officio, and three other members, to be elected annually by ballot, who shall meet at the call of the president and have charge of such matters of business relating to the association as shall be necessary to attend to in the interval between the annual meetings, and it shall be their duty to report such action as they may take to the next regular meeting of the association.

ARTICLE XI.

CHANGE IN CONSTITUTION.

This constitution shall not be changed except by a vote of two-thirds of the members at a regular annual meeting held one year from the date on which the proposed alteration or amendment has been first presented.

BY-LAWS.

(1) The time of meeting of this organization shall be fixt by the association.
(2) Order of business:
    1. Calling the roll of membership.
    2. Reading of minutes of previous meeting.
    3. Admission of new members.
    4. Reports of committees.
    5. Election of officers.
    6. Appointment of committees.
    7. Unfinished business.
    8. New business.
    9. Adjournment.

INSTITUTES IN THE SEVERAL STATES AND TERRITORIES.

ALABAMA.

The farmers' institute movement in Alabama began in the latter part of the decade 1880–1889. Each year during that period a few farmers' meetings were held by the staff of the agricultural college experiment station in cooperation with the State commissioner of agriculture.

Most of these meetings were in connection with those held at that time by the Farmers' Alliance. This association soon became involved in political difficulties that affected its influence, in consequence of which all meetings called for farmers for several years thereafter were looked upon as being prospective political schemes and were accordingly avoided by the country people.

In the year 1892, C. A. Cary, of the Alabama Polytechnic Institute, began holding a series of meetings in the various counties under the general direction of that institution. The meetings during the first year had a very small attendance, but when a second was held in the same locality a larger and more interested audience was always present. Gradually the confidence of the farming people was regained, and the institutes are highly regarded by the farmers as substantial aids in the improvement of their agriculture. During the period just referred to the lecturers at the institutes dealt almost wholly with the live-stock industry—the diseases of live stock, the caring and feeding of domestic animals, etc.

After about five years of work of this character by Dr. Cary, assisted from time to time by the members of the staff of the agricultural experiment station, the late William Leroy Brown succeeded in inducing the board of trustees of the Alabama Polytechnic Institute to appropriate the sum of $400 annually for farmers' institute purposes. This amount was continued each year until three years ago, when it was increased to $600 per year, and in 1904 was still further increased to $800.

The condition and progress of the institute work is exhibited in the following statement covering the past six years, showing the number of institutes held, the counties visited, and the attendance:

County institute meetings in Alabama.

Year ended	Institutes held.	Counties visited.	Attendance.	
			Total.	Average.
July 1, 1899	21	21	1,572	78
July 1, 1900	14	13	701	50
July 1, 1901	18	17	1,112	62
July 1, 1902	8	8	518	65
July 1, 1903	22	21	2,630	119
July 1, 1904	24	23	3,639	152
Total	107	103	10,172	95

There is no State law regulating or controlling the work. What is being done is wholly under the direction of the board of trustees of the Alabama Polytechnic Institute and of the agricultural experiment station. This body, as has been intimated, appropriates all of the money that is used for conducting the institute work and authorizes the members of the faculty of the Polytechnic Institute and the staff of the experiment station to render such assistance in lecturing before these meetings as they may be able, not to interfere with their regular work in the institutions to which they belong.

The director of institutes is appointed by the board for a period of one year to act as their representative.

There are no permanent local institute organizations in the State. The arranging of the dates, selecting places, and the preparing of the programs are all in the hands of the State director.

ALASKA.

Farmers' institutes have not been organized in Alaska, but the special agent in charge of the experiment station at Sitka, as he visits the various districts, takes advantage of the opportunity to give advice as to more advanced methods that might be employed in improving the agriculture of the several localities.

ARIZONA.

The farmers' institute movement in Arizona originated in 1895. On October 18 a convention of farmers, fruit growers, and stockmen assembled in Phoenix in response to a call issued by the agricultural experiment station and the Phoenix Chamber of Commerce. The meetings continued for two days. William Stowe Devol, director of the experiment station, was elected chairman, and Bruce Perley, of the Phoenix Chamber of Commerce, secretary. The program consisted of papers and addresses upon subjects of importance to those in whose interest the convention was called. Among the topics discust at this meeting were economical distribution of water, farming in Arizona, cattle feeding, alkali, citrus fruits in the Salt River Valley, etc.

A similar meeting was held October 21 and 22, 1898, in Phoenix, and in 1899 eight farmers' institute meetings were held—two at Mesa City and one at each of the following places: Tempe, Buckeye, Glendale, Safford, Thatcher, and Pima. These institutes were organized and conducted by the staff of the agricultural experiment station, who lectured at the meetings and bore so much of the expenses as was connected with the payment of the lecturers and their transportation to and from the several points.

Institute meetings were held each year thereafter, being conducted under the direction of the University of Arizona. Until 1903 the entire expense attendant upon this work was borne by the university and the agricultural experiment station. In 1903 the legislative assembly passed an act providing for the establishment of "farmers' institutes, and short courses of instruction" thruout the Territory and appropriated the sum of $2,700 for the purpose of meeting the expenses. The law places the control of the institutes in the hands of the board of regents of the university.

The institute work for the year 1904 consisted of three weeks of lectures at Thatcher Academy, Thatcher, Ariz., on subjects relating to soils, irrigation, alkali, pruning of fruit trees, plant lice, plant diseases, dairying, and feeding. There was an average attendance of about forty persons at each meeting and the lectures were by two members of the experiment station staff, who averaged two hours a day for fourteen days. The direction of the institute work has been placed, by the regents of the university, in the hands of the director of the agricultural experiment station.

ARKANSAS.

Farmers' institutes have not been organized in Arkansas.

CALIFORNIA.

From the establishment of the university in 1868 the members of the teaching staff of the college of agriculture participated in the proceedings of societies and conventions devoted to agricultural progress and the dissemination of agricultural information. Such association with practical agriculturists secured important results. It brought the institution and its purposes directly to the attention of those whom it aims to benefit and won their interest and support; it assisted the members of the college staff by increasing their knowledge of agricultural conditions and needs; it also, to some extent at least, gave the staff opportunity to observe the natural resources and characteristics of the State. Since, therefore, all possible participation in agricultural assemblies had been gladly undertaken, an opportunity for freer intercourse with the people in their local meetings was welcomed. This opportunity arose with the request from the California State Grange, addrest to the regents of the university, that farmers' institutes be undertaken under the auspices of the University of California, and the regents deemed it fitting to undertake an extension of the instructional work of the college of agriculture through the farmers' institute method. This action was taken by the regents in March, 1891; the beginning of institute work under that name in California was in April, of that year, and E. J. Wickson of the university was placed in charge of the work in addition to his duties as instructor in agricultural practice.

It was decided by the regents of the university at the inception of the work that the institute effort should be directed to those parts of the State where greatest interest was manifested and widest cooperation possible. During 1894 and 1895 these points were clearly in southern California, and, to specially minister to and to promote this interest, A. J. Cook, of Pomona College, Claremont, Los Angeles County, was designated by the regents as university representative in farmers' institute work in southern California.

During 1896–97 farmers' institute work was prosecuted with more vigor and to a greater extent than previously, and the responsive welcome from the people in all parts of the State was proportionally wide and warm. This result was directly due to an initiative on the part of the regents of the university. At the meeting on June 9, 1896, a special committee of ways and means, composed of Regents Reinstein, Black, and Rodgers, submitted a report embodying, among other important propositions, a plan for promoting the agricultural interests of the State, which was adopted by the board. The following reference to the institutes was made:

> The board of regents of the University of California has arranged to hold thruout this State fifty meetings of those engaged in occupations dependent on the soil, at which meetings the representatives of the University of California will seek to bring about such a relation between that university and the agricultural interests of the State as shall minister to the welfare of all concerned.
>
> These meetings are expected to strengthen the farmers' institutes already organized and to further the creation of new farmers' institutes and local farmers' clubs, the eminent utility of which is universally admitted.
>
> A prominent purpose of these meetings is to obtain the opinion of those interested in agriculture thruout the entire State as to the best means of spreading and practically applying the scientific teaching and knowledge of the University of California on agriculture and other industrial subjects. With the aid of such opinions it is expected to plan, as soon as possible, the system best calculated to accomplish that result and thereby increase the value and variety of the products of the soil of this State.

The superintendent was instructed to carry out this plan for the extension of farmers' institute work. Edward F. Adams, of Wright's, was appointed organizer for the portion of the State north of the Tehachapi Mountains; and A. J. Cook, of Claremont, was continued as organizer in his district. The result was a notable increase in the number of institutes and in the interest awakened thruout the State. After a year of very effective service Mr. Adams retired, as his time was fully required by other pursuits.

The success of the first year's work under this broader plan induced the regents to make provision for wider and more systematic work during the fiscal year 1897-98. On July 13, 1897, a new university department was created under title "The Department of University Extension in Agriculture," of which Professor Wickson was designated "superintendent," and two assistants were provided, to be known as "conductors of farmers' institutes." D. T. Fowler was chosen for the region north of Tehachapi and A. J. Cook continued for the region south of Tehachapi.

In March, 1903, the institute work, which had been carried on since 1891 by the University of California by appropriation from its general funds, was taken up by the State and direct appropriation made for its maintenance by the enactment of a law appropriating $6,000 per year for two years.

In that same year Mr. W. T. Clarke, who had served as field entomologist of the experiment station, was chosen assistant superintendent of university extension in agriculture, to assist in the farmers' institutes and to have special charge of reading and correspondence courses which were formally established.

This work was begun in June, 1904, and during the first year 175 students were registered in the course. These students were scattered thru 29 of the 57 counties of the State. Eighty per cent of the students (140) were directly engaged in farming, while the other 20 per cent were found in other pursuits. The work done by these students showed an intelligent and healthy interest.

From many points of view institute work in California has been pronounced very effective and satisfactory, and a growing demand has been manifested for it. The most tangible measure of this is shown in the average number of institutes from year to year, as follows: 1891 to 1895, 12; 1896, 52; 1897, 78; 1898, 86; 1899, 80; 1900, 81; 1901, 82; 1902, 71; 1903, 74; and 1904, 113.

Attendance has also increased, the annual average from 1898 to 1903 being estimated at 23,000, and the record of attendance, according to the method suggested by the American Association of Farmers' Institute Workers, yielding a total for 1904 of 43,680.

COLORADO.

The secretary of the State board of agriculture of Colorado, under date of March 1, 1905, states that "it is impossible to furnish any kind of a history of the farmers' institute movement in this State."

The data, therefore, given in the following account of the institute work in Colorado, are taken from a paper by A. C. True and F. H. Hall, printed in 1896,[a] and from a history of farmers' institutes prepared by L. H. Bailey, published in February, 1900.[b]

In the paper by True and Hall this item appears: "In 1879 Colorado joined in the movement (institute) with a meeting held at Fort Collins, November 26, in the management of which the local organization and the State board of agriculture cooperated."

Professor Bailey, writing in February, 1900, states that—

> No direct appropriations were made by the general assembly during this year (1891) for the purpose of supporting and conducting farmers' institutes. The State board of agriculture set aside a certain sum to be used for the purpose of defraying the expenses of professors attending such institutes held in different parts of the State. Since the year 1888 a record had been kept of the amount expended for this purpose, which is as follows: For the year 1888, $99.55; for the year 1889, $56.60; for the year 1890, $121.80; for the year 1891, $90; for the year 1892, the sum of $500 had been appropriated for said purposes.
>
> The farmers' institutes in Colorado are held under the auspices of the State agricultural college. There is no definite number held each year; they have varied from about six to twenty. The meetings are not regularly distributed over the State. They are held entirely in the irrigated districts, and at least one-third of them are held in connection with meetings of local Pomona granges. There are also several local organizations which apply to the college for speakers to hold and conduct the meetings. There is no definite sum available for the institutes; each locality is expected to pay the expenses of the room in which the meeting is held, of printing programs, and other local expenses. The railroads furnish free transportation and the college pays the rest of the traveling expenses; also the hotel expenses, if there are any, altho the local people are very likely to take care of the speakers while they are in town. On the average there has been less than $150 a year spent by the college on these institutes. There is no State department of agriculture. There is a co-called State board of agriculture, but this is merely the legal title for the trustees of the State agricultural college.

From the report of the institute director for the year ended June 30, 1904, the following statistics are taken:

> The funds with which to carry on the work are contributed by the State agricultural college. The total expenses last year (1903-4) were $517. Fifteen institutes were held, made up of 36 sessions, and the total attendance was 1,660. The lecture force was provided from the faculty of the agricultural college and experiment station staff. Twelve persons were sent out on this service, contributing in the aggregate forty-eight days of time.

The legislature at its session of 1905 appropriated the sum of $4,000 annually for the purpose of organizing and conducting farmers' institutes each year in each agricultural county of the State and made it the duty of the State board of agriculture, thru its officers and those of the State agricultural college, to organize and conduct these institutes.[c]

CONNECTICUT.

The late Doctor Bushnell, of Hartford, in an address before the Hartford County Agricultural Society about fifty years ago, speaking of the deserted and feeble churches in the country districts said: "It would seem to me that as a remedy, rather than sitting in conferences to discuss the question, we should form farmers' clubs to revive the agricultural life in these communities."

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[a] Experiment Station Record, vol. 7 (1896), p. 638.

[b] U. S. Dept. Agr., Office of Experiment Stations Bul. 79, p. 10.

[c] U. S. Dept. Agr., Office of Experiment Stations Bul. 135 (Revised), p. 10.

County and local agricultural societies were formed in Connecticut early in the last century. The desire for additional knowledge which these encouraged led to the establishment of the State agricultural society in 1852 and to the organization of the State board of agriculture in 1866. The first secretary of the old State agricultural society, Henry A. Dyer, who was secretary until his death in 1859, and later T. S. Gold, who was associated with Mr. Dyer, afterwards was secretary for thirty-nine years, did much to encourage a desire for more knowledge in agriculture, and laid the foundation of the modern farmers' institute system as it is in operation in Connecticut to-day.

The State board, among its other duties, held each year a three-day meeting for lectures and discussions and numerous one-day meetings whenever and wherever circumstances demanded it.

The three-day meetings usually had one central topic about which minor ones clustered, but of kindred character, such as dairying, fruit culture, good roads, etc. A gentleman who was somewhat skeptical as to the value of the three-day meetings, after visiting a meeting of this character, exprest himself as satisfied, since what he had seen had convinced him "that it took about three days for the farmers to get red-hot in discussing any question."

The single-day meetings were held to carry a subject to the rural districts for the information of all classes, some of whom might not come to the large meeting, and yet would be glad of the opportunity to spend a day or an evening at a meeting near their homes, particularly when some new or striking improvement in agriculture was before the people for discussion.

The history of the farmers' institute movement in Connecticut would be incomplete if a notable meeting held at New Haven in 1869, under the auspices of Yale University, were omitted. This meeting marked an era in agricultural education. Dr. John A. Porter, professor of organic chemistry in the Sheffield Scientific School at Yale, with other members of the faculty, planned for a four-weeks' convention at New Haven for lectures and discussions on matters pertaining to agriculture. This was under the patronage of the Sheffield Scientific School, then in its infancy.

Three sessions were held daily for four weeks, beginning February 1, and three to five lectures were delivered each day. The subjects were classified under four heads, and a week was given to the consideration of each. The first week was given to agricultural chemistry, the second to pomology, the third to agriculture proper, and the fourth to domestic animals. There were 26 speakers on the program, most of whom gave two or more lectures. The lecturers were drawn from Yale University and from all over the Union—practical and scientific men. Among the young men were Professors S. W. Johnson, W. H. Brewer, Benjamin Silliman, jr., and T. S. Gold. The great strength of the meeting was in the presence of a number of successful, practical men of national reputation, such as Marshall P. Wilder, of Boston; John Stanton Gould, of Hudson, N. Y.; Cassius M. Clay, of Kentucky, and others of equal celebrity and reputation.

The New York Tribune sent its representative, Mr. Henry S. Olcott, and published a daily report. The notes were collected and printed in a small volume entitled "Outlines of the First Course of Yale Agricultural Lectures." In this report occurs this comment on the lecture on Sheep Husbandry.

> A certain shepherd lecturer at a farm school in Saxony illustrates his lectures on breeding by presenting before his class sheep of various breeds and diverse qualities. So far as my information extends it has never been attempted in this country before to-day, when T. S. Gold placed on the stage a Cotswold, a Merino, and a Southdown. * * * It is a new and a most capital idea, and hereafter he who will lecture on sheep without the living illustrations ready for reference will be behind the age.

The success of this course both in speakers and attendance was such as to warrant permanence in an annual form, but the breaking out of the civil war and the early death of Professor Porter prevented even a single repetition.

As before stated, the State board of agriculture holds many single-day institutes, and various associations or societies supplement this service by institutes or field-day meetings, as the Dairy Association, the Pomological Society, the Forestry Association, the Grange, and other associations each in their own interest, working jointly or separately, but in harmony for the general good.

The methods used by these different organizations in carrying on their work of disseminating information are entirely in their own discretion. Each has an institute committee appointed to have charge of the institute work. The board of agriculture requires that localities applying for institutes shall furnish a suitable hall, provide local transportation for speakers and visitors, music, if desired, and entertain by collation or otherwise unless there are convenient hotel accommodations. The board pays for printing, traveling expenses, and services of speakers.

The colleges and experiment stations furnish speakers, men who join science and practise to meet men whose practise tests the theories of science.

There are no specific local organizations for conducting institutes, but the superintendents depend upon the local granges and farm clubs for cooperation. There is no special law making appropriation to farmers' institutes, the expenses being met out of the general appropriation made to the State board, the Dairy Association, and the Pomological Society

DELAWARE.

The first farmers' institute in Delaware was organized as the "Farmers' Institute of New Castle County" at a meeting held at Delaware College, Newark, on February 21, 1889. Officers were elected, including a president, vice-president, secretary, treasurer, and an executive committee. A constitution and set of by-laws were adopted. Twenty members joined, paying the fee of $1, which was fixed as the cost of annual membership. On March 11, the same year, a second meeting was held at the same place, when several addresses were made on practical farm topics, and some phases of the State and county government were discust. This meeting was largely attended, farmers being present from all parts of the county.

At the time this organization was formed a farmers' institute bill was pending in the Delaware legislature, then in session, and was passed without opposition on March 29, 1889. The act provided for the holding annually of at least one farmers' institute in each county for the discussion "orally or by written essays or papers of agricultural and kindred matters and for the dissemination of agricultural knowledge among the farmers of this State." Each county institute organization consists of a president, vice-president, secretary, treasurer, and an executive committee of not less than five nor more than nine members. The act appropriated $600 annually for bearing the expenses of the institutes, which is apportioned $200 to each county.

Under this act institutes were organized in Kent and Sussex counties on May 18, 1889, but for some reason no meeting was called in New Castle County until January 18, 1890, when a meeting was held. The organization formed the previous March was disbanded and a new organization was formed according to the act of the legislature. The institute of each county was absolutely independent of those in the other counties. All three organizations at once became very active and useful. At first the meetings usually consisted of a single session, or rarely of two sessions. The subjects discust were topics relating to practical farming and to the management of county and State affairs, good roads, methods of taxation, honesty on the part of county and State officials, civic betterment, and educational problems. Many of these addresses were published in pamphlet form and distributed to the farmers of the State. For several years after the institutes were organized the speakers were nearly all practical farmers and leading citizens of the county in which the institute was held, in addition to the officers, workers, and teachers in the agricultural college and experiment station, who were called upon freely and rendered very efficient and acceptable service. From time to time, also, specialists from other States were secured.

These single-session institutes were continued as the general practise in all three counties until the winter of 1894–95, when a number of all-day meetings were held in Kent County and were addrest by prominent institute workers from outside the State, as well as by local speakers. These meetings were so successful that one-day meetings were continued, as a rule, in Kent County until the winter of 1899–1900, when Kent and Sussex counties joined in holding a series of meetings of two days each. These meetings were well advertised, interesting programs were arranged, and were even more successful than the one-day institutes, and therefore two-day institutes have been the rule since that time.

A feature of the work which proved of great interest and value consisted of schoolhouse meetings. In the winter of 1895–96 Sussex County was almost entirely covered by such meetings, held on successive nights in adjoining districts. Each meeting helped to advertise those following, and, as a rule, every farmer in the school district attended and often followed it up by going to his neighboring school district the following night. The next winter Kent County was covered in a similar manner, and some of these schoolhouse meetings have been held in all three counties since.

The effect of the farmers' institute movement in the State has been marked. The farmers have been stimulated to adopt better methods in the practical operations of the farm and to make their homes more comfortable and happy. Public sentiment has been aroused upon a number of important questions, and beneficial legislation has followed.

In the winter of 1903 the legislature authorized the State board of agriculture to appoint a State director of farmers' institutes to cooperate with the several county organizations to assist in securing speakers and arranging and advertising the meetings, thus furnishing a means of placing the system under one head and in this way simplifying and enlarging the work. The director is paid out of the funds of the State board of agriculture, which is equivalent to making a small appropriation to the institutes.

FLORIDA.

In September, 1898, a resolution was passed by the board of trustees of the State agricultural college to the effect that "A farmers' institute under the direction of the agricultural department of the college be held in each county of the State, provided the railroads furnish transportation for the speakers and the local committee furnish entertainment."

Prior to this date farmers' meetings were held in various parts of Florida by those interested in better agriculture, but nothing definite had been done looking toward any permanent organization of the work.

Under the resolution of the board just referred to, a number of successful meetings were held in different parts of the State, speakers being furnished by the Florida Agricultural College and by the agricultural experiment station.

In May, 1901, the legislature, recognizing the importance of the work, granted an appropriation of $5,000 for two years for farmers' institutes. During 1903–4 the expenses were met from an appropriation made by the State to the board of trustees of the Florida Agricultural College in the following terms: "For holding farmers' institutes, $2,500."

The superintendent of institutes is appointed by the board of trustees of the college and given authority to make all necessary arrangements for holding institute meetings. In 1894 15 institutes were held, consisting of 32 sessions, and over 1,600 persons were reported as being in attendance.

Institute meetings are held only upon request of the locality desiring the institute. A local chairman for each institute is appointed by the State superintendent of institutes, who looks after the advertising and the securing of a suitable place for holding the meeting.

GEORGIA.

The farmers' institute movement in Georgia began in 1899, at which time the Atlanta Semi-Weekly Journal made an appropriation of $750 to hold a series of farmers' institutes under the management of the agricultural editor of that paper. Fifty institutes were held that year. This appropriation, however, was not continued, and the work was suspended until 1903, when it was taken up by the University of Georgia. In that year the trustees of the State university made an appropriation of $1,000 for farmers' institute purposes. A State director was appointed and instructed to hold one farmers' institute meeting in each senatorial district in the State. Harvie Jordan, of Monticello, was selected for this position. During that year he held 44 institutes, having an attendance of 8,250 farmers. The expenses of the lecturers, office expenses, and publication of bulletins of information were all provided for and paid out of the $1,000 appropriated.

In 1904 the general assembly of Georgia made a direct appropriation for farmers' institutes amounting to $2,500. The trustees of the State University continued the appropriation of $1,000, making available for institute purposes for that year $3,500.

The institutes are held, one in each senatorial district, under the rotation system of changing to different counties in each district each year. The total attendance for 1904 was about 22,000, and from 4 to 6 lecturers were present at each institute. A women's session presided over by a lady lecturer has been made a part of every institute and is proving a popular movement, attracting the wives and daughters of farmers to these agricultural meetings.

The institute work has been placed by the board of regents under a board of control consisting of the chancellor of the State university, president of the State college of agriculture, and the director of farmers' institutes.

The dates, places, and programs for the institutes are arranged by the State director, and the meetings are usually advertised at least two weeks in advance by means of the county press. In 1904 14 lecturers were upon the State force, 8 of whom were representatives of the faculty of the agricultural college and of the experiment station staff.

HAWAII.

Societies for the promotion of agriculture have been in existence in Hawaii for almost half a century. An effort was made in 1898 to form an organization on the plan of the farmers' institute, but for lack of public interest the movement failed. Each year thereafter up until 1902 similar efforts were made with like results. On the 25th of January, 1902, thru the efforts of the local Federal agricultural experiment station, a meeting was held at Oahu for the purpose of organizing a permanent society to encourage and help diversify agriculture in the Territory and for the founding of permanent homes thruout the country. It was further the purpose of the organization to have the society become the head of a movement in the Territory to give aid to all the farming districts of the islands in every possible way and to encourage the promotion of local organizations for the study of local conditions and problems.

An organization was effected and the following offices were created and filled by the following persons: President, Jared G. Smith; vice-president, T. F. Sedgwick, and secretary-treasurer, D. L. Van Dine.

The president was empowered to appoint all committees necessary to further the work of the institute, to act in the organization and work of branch or local institutes, to make arrangements for the regular meetings of the institute, to appoint committees on the nomination of officers, to have charge of the work of getting up the programs of the meetings, and to be a member, ex officio, of all such committees. The regular meeting was to be called once in three months, the date and place of meeting to be decided by the president. It was further decided that at all such meetings a paper should be read on subjects dealing with matters of importance to the development of agriculture in Hawaii by men thoroly competent by experience and training to present such information, and that such papers should be followed by discussions, the discussions to form an important part of the program.

The farmers' institute began with a membership of 15. At the present time (1904) there are 72 active members enrolled and 2 honorary members—the governor of the Territory and the superintendent of public instruction. Six regular meetings of the institute were held during the year—four on the island of Oahu and two on the island of Hawaii. On Hawaii a branch organization was formed which is to meet once a month during the year.

There are no salaries connected with the society. The money has been provided by the officers of the institute with the aid of some of its members.

The following extract from a letter addrest to the president of the farmers' institute by Sanford B. Dole, governor of Hawaii, under date of January 24, 1902, shows the interest that the Territorial government has manifested in the organization of the institute work. The governor writes:

> It is with great pleasure that I have learned of your intention to organize a farmers' institute upon a permanent basis. It is an enterprise which if perseveringly conducted can not fail to be of great benefit to the farming interests of the Territory. * * * I recognize the probability that general farming here must develop slowly. Individuals here and there will succeed because of intelligent and skillful cultivation of the soil and a careful study of the markets. Farmers' institutes will promote such cultivation and such study of the markets amongst the whole farming fraternity.

During the year ended June 30, 1904, four institutes were held, consisting of eight sessions, having an attendance of 200. All of the meetings were conducted by members of the experiment station staff. A report of the proceedings was published and 1,000 copies distributed among the farmers of the Territory. The present director of institutes is Jared G. Smith, special agent in charge of the agricultural experiment station, Honolulu.

IDAHO.

Prior to 1898 very little had been done in conducting institutes in Idaho. A few meetings were held under the supervision of Charles Fox, director of the experiment station. The work was again taken up in the fall and winter of 1898, and several institutes were organized in southern Idaho and a few in the northern part of the State. These meetings, the first of which was at Moreland in December, 1898, were well attended, considering the fact that they were the first institutes ever held in the localities visited. Local committees were appointed in each of the towns where meetings were held and work was fairly begun. From that date the work has been kept up and has grown in interest until in many localities it is not easy to secure rooms large enough to accommodate the people. The number of meetings held yearly has increased from ten or fifteen the first year to more than thirty during the present year.

In 1900 the legislature made a biennial appropriation of $2,000 for institute work, and this has been maintained at each of the biennial sessions since. An effort was made to increase the amount at a recent session, but failed on the ground of economy in State affairs.

The director of the State experiment station is superintendent of institutes in the State and conducts all correspondence regarding the meetings. The dates are arranged by the superintendent and programs are made out in cooperation with a local committee, which is known as the institute committee of the locality. No county organizations have been made, owing to the difficulty of communication and transportation. The plan followed seems to work very satisfactorily and the interest is steadily increasing. It is becoming a question of how to meet the demands for more meetings and to secure a greater number of instructors. The last demand is partially solving itself in that men are developing a capacity for this work in various sections of the State and many will no doubt soon be able to render assistance on the lecture platform.

ILLINOIS.

The first farmers' institute held in Illinois of which record appears to have been made was held under the auspices of the Illinois Industrial University at Champaign, January 12 to 22, 1869.[a]

In the announcement of this meeting it was stated that the course would continue for eleven days, with three sessions each day; that there would be no charge for admission, and that each lecture would be followed by a discussion in which all were expected to participate.

The topics discust included: Agricultural Facts and Theories, by J. M. Gregory, regent of the university; The Natural Sciences in Agriculture, by Prof. A. P. S. Stuart; The Soils of Illinois, by H. C. Freeman, of the State geological survey; Management of Soils, by Dr. John A. Warder; Grass, by Dr. L. D. Morse, editor of Journal of Agriculture; Corn, by M. L. Dunlap, agricultural correspondent, Chicago Tribune; Wheat, by W. C. Flagg; Potatoes, by Jonathan Periam, superintendent practical agriculture; Root Crops, by Jonathan Periam; Agricultural Bookkeeping, by Capt. Ed. Snyder, instructor in bookkeeping; Orchard Fruits, by Dr. E. S. Hull, of Alton; Grapes, by Hon. George Husmann, of Herman, Mo.; Small Fruits, by Samuel Edwards, Lamoille; Breeds of Cattle, by Sanford Howard, secretary, Michigan State Board of Agriculture; Horses, by Col. N. J. Coleman, editor of Rural World; Swine, by Hon. Elmer Baldwin; Sheep, by A. M. Garland, president of Sheep Growers' Association; Agricultural Botany, by Assistant Professor Albert J. Burrill; Vegetable Physiology and Economy, by John H. Tice, secretary of Missouri Board of Agriculture; Rural Economy and Rural Life, by Dr. J. M. Gregory; Fences and Hedges, by Dr. John A. Warder; and Timber Growing, by O. B. Galusha.

The papers and discussions were published in full in the above named university report.

Dr. L. D. Morse, St. Louis, editor of Journal of Agriculture and secretary of the Missouri Agricultural Society, published most of these papers in the Missouri Agricultural Report for 1868. He said of this meeting:

> Thus was inaugurated a new and probably important movement in western agricultural education and improvement. Regarding it as an experiment, it may safely be recorded as resulting successfully. The lectures and discussions were attended by the students of the university, seventy or more in number, quite largely attended by the citizens of Champaign and vicinity, and there was a goodly number from various parts of the State. The lectures were, most of them, of an eminently practical character and the discussions lively and interesting.

It is very significant that the early promoters of industrial education, the advocates of the agricultural college, should also have been the prime movers in developing the farmers' institute idea.

In 1870 three farmers' institutes were held under the auspices of the industrial university. In 1871 four institutes, in 1872 five institutes, and in 1873 eight institutes, which appears to have been the supreme and last effort of the industrial university to hold farmers' institutes at other places than at the university.

The expenditures for these institutes had been limited to about $500 per annum. No mention of institutes was made in the university report for 1874. In 1875 the following resolution was adopted by the board of institutes:

> *Resolved*, That the corresponding secretary be authorized to arrange for farmers' institutes without expense to the university and to call upon professors of the university for such services as lecturers as they may be able to render without detriment

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[a] Ann. Rpt. Ill. Indus. Univ., 1868-69, p. 120.

to their work with their classes: *Provided*, That the traveling expenses of such professors and lecturers shall be paid by the localities benefited by such institutes or without charge to the university.[a]

In this early effort to conduct farmers' institutes and build up an agricultural college the farmers and the university people mutually failed to understand each other's conditions and needs, and the effort was short-lived and a comparative failure. The university authorities directed their enthusiasm energy, and money to other educational lines to the neglect of agriculture, and the farmers' institutes, so far as the university was concerned, were thrown upon their own resources. The institute idea, however, survived, being kept alive by the annual meetings of the Illinois Horticultural Society, Dairymen's Association, Wool Growers' Association, Swine Breeders' Association, and the Tile-makers' Association, all of them strong organizations, well equipped with practical, experienced men and competent instructors in their several special lines of industry.

The decade of 1870 to 1880 was one of great activity in organizations of farmers, the common purpose being redress from the extortions of railroads and regulation of freight rates. Granges and farmers' clubs and associations, State, county, and local, were in evidence everywhere.

About 1880 the Illinois State Board of Agriculture began, officially, to recognize the value of the farmers' institutes, and took up the work where the industrial university abandoned it, by cooperating with local organizations in the arrangement of programs and in the payment of the expenses of speakers. The attitude of the board of agriculture toward farmers' institutes is expressed in an address by J. R. Scott to the board January 3, 1882.

In the course of his address President Scott, in speaking of the farmers' institutes and their value in improving the condition of the farmers of the State, said: "It is recommended that the board provide for the holding, during the present year, at least one institute meeting in each Congressional district of the State. It is further recommended that a reasonable appropriation be made by the board for the holding of institute meetings."[b]

The board of agriculture approved the president's recommendations in regard to farmers' institutes and advised the holding of at least one farmers' institute in each Congressional district during the year 1882.

Two institutes were held in 1882 under the direction of the State board of agriculture. Several of the papers read at these institutes were published in Transactions, Department of Agriculture of Illinois, vol. 20.

The number of institutes held under the auspices of the board of agriculture and by private enterprise in the several counties increased from year to year, but no record of the number of these institutes seems to have been made till the publication of Transactions, Department of Agriculture of Illinois, vol. 25, wherein it is stated, giving place and date of meeting, that 9 Congressional district and 33 county farmers' institutes were held in 1887.

The first appropriation for farmers' institutes by the State of Illinois was made in 1889, $100 for each Congressional district, to be expended under the direction of the State board of agriculture.

In 1891 an appropriation of $50 was made to each county farmers' institute and the management of such institute placed entirely in charge of the county organization, which reported to and drew the fund thru the State auditor. This plan and appropriation of $50 to each county was continued till 1897; the number of counties holding institutes and drawing in whole or in part the $50 ranged from 35 to 64 in number each year.

In 1895 the Illinois Farmers' Institute was created, providing for a State round-up institute meeting, a director for each Congressional district, officers of the board, and the publication of 10,000 annual reports. No appropriation was made for this State organization. Two State institutes, however, were held and annual reports of the same published in 1896 and 1897.[a]

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[a] Rpt. Ill. Indus. Univ., Vol. VIII, p. 101.

[b] Trans. Dept. Ag. Ill., 1881, vol. 19, p. 223. Farmers' Institutes.

In 1897 an appropriation of $7,000 per annum was made for the use of the Illinois Farmers' Institute and $50 per annum additional for each county institute, the work to be carried on jointly by the State and county organizations without destroying the autonomy of the county institute.[b]

These amounts were increased in 1899 to $8,000 per annum for the State and $75 per annum to each county institute.[c]

In 1901 an additional appropriation of $2,500 per annum was made to the State institute for the purchase of books for and the maintenance and management of the Illinois Farmers' Institute free libraries. These libraries consist of collections of about 45 volumes, each set being put up in a substantial case, and are for the free use of rural communities. The community securing a library pays the express charges to and from the central office in Springfield and has the use of a library for six months. These libraries have proved very valuable adjuncts to the institute work. Two hundred libraries are now in use and more are being equipped.

In 1901 the number of annual reports published was increased from 10,000 to 20,000 per annum.[d]

The general assembly of 1903 renewed the appropriation of $75 per annum to each county institute, $2,500 per annum for free libraries, provided for the salary of secretary of $2,000 per annum, and $7,500 for general expenses, a total of $19,650 per annum for farmers' institutes.[e]

During the year ended June 30, 1904, 105 institute meetings were held; of these, 63 were two-day institutes, with from four to six sessions each, and 42 were three-day institutes, with from six to eight sessions each. The total attendance was 84,681, an average of 806 for each institute. The total cost, not including the expenses of the State institute, officers, and directors, was $10,673.79. Average cost per institute, $101.65. Of the above cost, $7,874.97 was paid from State funds and $2,798.82 by local and county contributions. Total number of days on which institutes were held, 248. Total number of sessions, 609.

A characteristic feature of the work of the farmers' institute is the cooperation of the Illinois Association of Domestic Science, which organizes clubs and associations in the several counties and cooperates with the State and county institutes in supplying numbers on the programs relating especially to home making and home keeping.

With the inauguration of the State institute began a campaign for the development of the Illinois College of Agriculture. It was largely thru the influence of the farmers' institute that an appropriation of $150,000 was secured for the college of agriculture building and a bill past requiring the trustees of the University of Illinois to devote one-half of the funds derived from the United States appropriations for industrial education to the maintenance of the college of agriculture.

After being divorced for over twenty-five years, the farmers' institute and the College of Agriculture were again united and began anew the development of an educational system on agricultural lines.

INDIANA.

The earliest mention of farmers' institutes in Indiana is found in the annual report of the State board of agriculture for 1881. This report covers the latter part of 1881 and the earlier part of 1882. At the January meeting of the Indiana Delegate and State Board of Agriculture, 1882, Allen Furnas, of Hendricks County, offered the following:

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[a] Rpt. Illinois Farmers' Inst., vols. I and II.

[b] Laws of Ill., 1897, p. 18.

[c] Laws of Ill., 1899, p. 21.

[d] Laws of Ill., 1901, p. 3.

[e] Laws of Ill., 1903, pp. 4-39.

Resolved, That it is the sense of this delegate body that the State board should create an agricultural institute, to meet once a year, to remain in session from ten days to a fortnight, for the discussion of matters pertaining to agriculture and kindred subjects.

This resolution was referred to a committee consisting of Aaron Jones, W. B. Seward, of Bloomington, and Mr. Sutherland, of Laporte. The committee reported on January 4 as follows:

We unanimously recommend:

(1) The holding of four institutes as a trial in this State, two to be held this winter and two in the month of December, this year.

(2) That the secretary of this board be authorized to receive proposals from different localities in the State for such institute and have the power to make appointments.

(3) That the town or locality expecting such institute must pledge itself to defray the expenses of such institute, including the providing of a suitable hall, warmed and lighted; and further, that the locality furnish at least one-half the papers on the program.

(4) That the State board of agriculture ask of the trustees of Purdue University that they send at least two of the faculty of that institution to attend each institute and lecture or read papers.

(5) That such institute hold two days with four or five sessions, as circumstances may seem to dictate.

(6) That the secretary of this board, with a local committee at the place of holding such institute, be empowered to make up the program for that special occasion.

(7) We further recommend that the legislature be memorialized for a special annual appropriation of $500 for the holding of agricultural institutes for the education of the farmers of our State.

In accordance with these resolutions two meetings were held in the spring of 1882, the first at Columbus, Bartholomew County, March 8 and 9, and the second at Crawfordsville, Montgomery County, March 22 and 23.

The board made an effort to locate and hold the two other institutes, but failed owing to the excitement occasioned by the political campaign of that year.

At the annual meeting of the State board of agriculture in January, 1883, the president of the board, in his annual address, advised the holding of farmers' institutes during the year, and the board of agriculture agreed to memorialize the legislature for an annual appropriation of $1,000 for defraying the expenses of the institutes. This application was not made by the committee of the board, as they "feared that it might jeopardize the appropriation for the interest on their bonds."

The next reference to the institutes by the board is in the minutes of the meeting of February, 1886. In these minutes this statement is found: "The executive committee in connection with the president was directed to outline a system for gathering crop reports and forming farmers' institutes thruout the State."

The next reference is found in the proceedings of the annual meeting of the State board of agriculture January 1, 1887. The committee, to whom the president's address of that board had been referred, reported that they were of the opinion that the legislature should appropriate a sum of money each year to be used by the State board for the purpose of sending a competent person out thru the State to work up what are called farmers' institutes. This was followed by a general discussion which terminated by passing the following resolution:

Resolved, That all that portion of the president's address and the report of the committee to whom it was referred on the subject of farmers' institutes be referred to the State board, with the request that they formulate a full set of rules for the organization of such institutes, and that the members of the State board shall take such steps as they may deem best to secure an organization in the counties and townships of their several districts.

Messrs. Seward, Mitchell, Simonton, and Lockhart were appointed a committee to formulate a system covering county institutes. This committee made its report at the January meeting in 1888. They stated that they had corresponded with officers and managers of farmers' institutes in the States of Illinois, Ohio, and Wisconsin, and after considering the institute work of these States were of the opinion that Indiana was in as good a shape to commence the work of holding farmers' institutes as some of these States were when they began their work, and they advised the holding of at least one institute in each county in the State between the date of their report (January, 1888) and March 1, and advised that the members of the State board of agriculture take charge of the work in their several districts and see that institutes are held. The recommendations of the committee were adopted and the board was instructed "to provide for a series of farmers' institutes to be held during the coming year, one such meeting to be held in each member's district."

At the annual meeting of the State board in January, 1889, R. M. Lockhart, chairman of a special committee of three appointed for the purpose of formulating a plan by which the work could be started in different parts of the State, reported that the committee had prepared what they conceived to be the best plan for immediate work and had it published in the Indiana Farmer, advising that at least one institute be held in each district between January, the date of the board meeting, and the first of the following April. He also stated for the committee, "We are glad to be able to report that a number of very interesting institutes have been held in the State."

In the report of 1888 the secretary of the State board, in speaking of the farmers' institutes in Indiana, stated that—

> Several institutes were held in different parts of the State during 1887 which, from reports submitted to the board of agriculture, were failures thruout as regards attendance. During the year 1888 just closed, however, success has crowned the efforts of workers in this field and notably different results have obtained in a very large number of places where institutes have been held. In many instances the institute has been maintained thruout the two days set apart for holding these meetings, and large crowds have come together in response to the call to hear addresses by learned gentlemen selected to conduct these institutes. * * * Among the institutes held programs were received at the office by the secretary of the board of agriculture from Rockville, Parke County; Peru, Miami County; Princeton, Gibson County; Laporte, Laporte County; Plainfield, Hendricks County; Franklin, Johnson County, and Anderson, Madison County.

The annual reports of the State board of agriculture contain accounts of but four institutes up to this time—the meetings at Columbus and Crawfordsville in 1882, and at Franklin and Anderson in 1888. The two first institutes were held under the direct control of the State board of agriculture. The Johnson County institute and the Madison County institute were under the joint auspices of the State board and local agricultural associations.

In 1887 a number of district meetings were held under the direction of R. M. Lockhart—one at La Grange February 14, another the next day (Wednesday) at Sycamore Corners, on Thursday at Kendallville, on Friday at Angolia, and at Waterloo on Saturday. The speakers at these metings were Professor Webster, of Purdue University, John B. Conner, editor of the Indiana Farmer, and Judge Robert W. McBride.

Mr. Lockhart reports that during 1887 he aided in organizing the institutes in twenty-two counties. In addition to these there were eleven others held at the following points: Goshen, South Bend, Laporte, Warsaw, Columbia City, Fort Wayne, Peru, Kokomo, Anderson, Muncie, and Richmond.

These early institutes were less like schools than farmers' institutes of the present day. Altho held in an irregular, somewhat spasmodic and very incomplete way, they doubtless did much to interest the people of the State in practical discussions on topics of everyday interest to farmers. With no public funds to draw upon, with no authorized and centralized control of the work, and dependent almost wholly upon local initiative, only a few favored localities could be expected to take an interest, and consequently receive the benefits of the work. The seed, however, was being sown in fruitful soil, as the later developments of the institutes revealed.

In consequence of the work that had been begun in 1882 the general assembly of 1889 past an act which had been presented by Hon. W. W. Robins, representative from Miami, known as house bill No. 430, organizing the farmers' institute under State control and appropriating $5,000 per year for institute support. The bill was approved by the governor March 9, 1889.[a]

In the autumn of that same year, 1889, the farmers' institute work was begun under State control. In order to comply with the institute act which required the holding of an institute annually in each county of the State, an effort was made to get the work organized in all of the counties the first year. This was found to be impossible, owing to lack of information and indifference on the part of the people in many localities. Institutes, however, were held in 50 counties the first season, 1889–90; in 41 of the remaining 42 counties the second season; in the third season, 1891–92, institutes were held in 90 counties, and in the fourth year in 89. Beginning with the fifth season, 1893–94, and continuing since, at least one institute has been held annually in each of the 92 counties of the State. At first the institutes were held almost exclusively at the county seats, altho in a few counties the plan has been from the first to hold the meetings successively at different points.

Beginning with 1898 a conference of institute officers and workers has been held in October of each year. In 1901 the general assembly increased the appropriation for farmers' institutes from $5,000 to $10,000 per annum. In the autumn of the same year, 1901, a women's conference was held for the purpose of considering what farmers' institutes might do for the women of the farm.

Beginning with 1901 two-day district farmers' institutes have been held annually in the month of August. The increased appropriation which became available in 1901 added largely to the number of institutes that were held, and from that time approximately half of the meetings have been held at outlying points near county boundaries.

For the purpose of carrying out the provisions of the institute act the board of trustees appointed a joint committee on institutes consisting of the president of the university, the director of the State experiment station, and the professor of agriculture of the university. This committee has direct charge of the institute work. The last-mentioned officer is the superintendent of institutes, and formulates plans for the approval of the committee and has immediate supervision of the work.

When the work was first organized under State control the members of the State board of agriculture were invited to take charge of the institute arrangements in their respective districts. Those who were willing to act were appointed to assist the general management in holding meetings in the several counties in their respective districts. Altho several members of the board of agriculture cooperated acceptably and effectively it was soon found desirable to appoint a suitable person within each county to take the local supervision of the work in charge. It became apparent that some form of local organization within each county was necessary to give standing and permanence to the work. Accordingly granges, agricultural societies, farmers' clubs, etc., were invited to take local supervision of the institute. Further experience demonstrated the necessity for having some form of local organization for the single purpose of holding farmers' institutes. Each institute was therefore requested to elect a chairman, who might be recognized by the general committee as the one having charge of the work in the county. A secretary was also elected and a little later a number of the counties elected or appointed vice-presidents for the several townships.

These local organizations, varying in character and not well knit together and often with no written or definite constitution, nevertheless answered the purpose very well for a number of years. With the increased appropriation of 1901 and the consequent management of the work it soon became apparent to the general committee that a compact, uniform, county system of organization would secure more effective local cooperation in carrying forward the work thruout the State. A form of constitution for the government of the local associations was therefore submitted to the annual conference of institute workers, which met in October, 1903. With some slight changes the proposed constitution was unanimously approved by the conference. It was then sent out to the several counties for adoption. During the season just closing, 1903–4, one-half of the counties have adopted the constitution substantially as presented. It is believed that within a year or two more when the purpose of the proposed constitution is better understood and its necessity becomes more apparent to the local societies it will be generally adopted as the working plan for conducting farmers' institutes thruout the State.

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 135 (Revised), p. 15.

The aim of the institute in Indiana is, largely—

(1) To give instruction that will be practically helpful to all classes of farmers and their wives in the performance of the everyday work of the farm and the farm home;

(2) To awaken a greater interest in the promotion of agriculture, betterment of the farm home, improvement of the highways, and advancement of the rural schools; and

(3) To heighten the attractions of farm life and interest the young people of the country to seek adequate preparation for the successful pursuit of agriculture.

The general plan is to hold one or more institutes in each county of the State during the institute season, November 1 to April 1. The county institute chairmen in the spring of each year advise the superintendent of institutes as to the dates and places desirable for meetings the subsequent year and the general theme which they deem proper to be discust. The superintendent then arranges the schedule of meetings and assigns speakers to each. The meetings are thrown into groups, usually three in each group, with two days of five sessions allotted to each meeting. Two State speakers attend each institute. The list of speakers and the schedule of the institutes are printed and sent out to officers and speakers before the opening of the institute season.

Three classes of meetings are held: (1) Local institutes in the several counties, usually two-day meetings; (2) two-day district institutes for a group of counties; and (3) a two or three day annual conference of institute officers and workers for the entire State.

The details of arrangements for the local institutes are left largely to the county chairmen and their associates. The district institutes are arranged for by the State superintendent in connection with the local committee of farmers and business men at the places where the meetings are to be held. The annual conference of institute officers and speakers is arranged for by the joint committee of institutes.

Indiana has no institute conductors. The county institute chairman is, as a general rule, the presiding officer and is in charge of the details of opening and closing the meetings, conducting the discussions, preserving order, etc.

Two official reports of each meeting are required—(1) from the secretary and (2) from the assigned speakers. These reports contain such matter as will inform the superintendent as to the character of the work done and aid him in planning for future work in the locality.

The securing of effective institute speakers is one of the difficulties that Indiana has endeavored to solve. In doing this it has been the aim to discover and develop practical workers from the ranks of the everyday farmers. The best possible workers in the State have been developed by means of the opportunities that have been given by the State director to acquire experience in the presentation of the particular subject with which they have had most experience. Specialists, agricultural experiment station workers, and the faculty of the school of agriculture are drawn upon to supplement the force of practical workers.

Two classes of local institutes in the counties have hitherto been held—(1) annual meetings, usually at the county seats, and (2) supplementary meetings at outlying points near county boundaries. By this means meetings have been much more equally distributed thruout the State than heretofore.

During the coming season the meetings will be apportioned in the counties in proportion to area. Each county having less than 200 square miles will be entitled to two days of institute work; each county ranging in area from 200 to 350 square miles will be apportioned three days of institute work; each county having over 350 and less than 500 square miles will be allowed four days of institute work, and each county having over 500 square miles will be granted five days of institute work.

The following table shows the number of counties holding meetings and the total number of meetings held each year; also the average and aggregate attendance since 1894, prior to which time no record of attendance was kept:

County institute meetings in Indiana.

Year.	Number counties holding institutes.	Total number institutes held.	Attendance.	
			Average.	Aggregate.
1889-90	50	50		
1890-91	41	41		
1891-92	90	102		
1892-93	89	95		
1893-94	92	95		
1894-95	92	97	118	11,446
1895-96	92	103	272	28,016
1896-97	92	104	232	24,128
1897-98	92	108	272	29,375
1898-99	92	102	250	25,500
1899-00	92	104	269	27,976
1900-01	92	104	279	29,016
1901-02	92	197	191	37,603
1902-03	92	179	192	34,226
1903-04	92	175	338	59,189

Beginning with 1901, when the increased appropriation for farmers' institutes became available, a few district institutes of two days each have been held in the late summer of each year. The management has three purposes in holding these district meetings—(1) to promote some special line of agriculture in a section of the State specially suited to its pursuit; (2) to afford high-class instruction that would prove helpful to the most intelligent and progressive men engaged in special agricultural pursuits, and (3) to awaken a wider interest in the subjects considered and to stimulate the workers in attendance to more earnest effort in behalf of the local institutes to be held during the winter months.

Beginning with 1898 an annual conference of institute officers and workers has been held at the university in the month of October. In holding these annual conferences several purposes have been kept steadily in view. The more important of these are: (1) To inform all the workers more fully as to the nature, scope, needs, and importance of the institute work; (2) to consider carefully the lines of work that should be undertaken; (3) to discover and adopt the best methods of advertising, conducting, and reporting the institutes; (4) to acquaint the workers with each other and thus develop and foster a spirit of good-fellowship and mutual helpfulness; (5) to give to the workers a higher and broader conception of the dignity and importance of the institute work and to inspire them to more diligent effort to accomplish the ends in view; (6) to enable the workers to meet from time to time prominent and widely useful men in the field of agricultural education and thereby acquire broader and truer conceptions of the importance and relations of the farmer; (7) to inspire a deeper love for agricultural pursuits and a more earnest desire for the betterment of agricultural conditions, and

(8) to arouse a deeper and more intelligent interest in the improvement of the rural home, the rural schools, and the rural highways as means for agricultural improvement and progress.

In August, 1901, a women's conference was held at the university. As a result of this conference women's auxiliaries to the farmers' institutes have been organized in a number of counties. In several of the counties these auxiliaries held independent sessions for home makers usually at the time of the annual institutes. In other cases these auxiliaries took charge of one or more sessions of the regular institute.

Exhibits of culinary, dairy, and cereal products are becoming increasingly common features of the farmers' institutes. When properly conducted these exhibits have been made educational in character and added greatly to the interest.

At the institute conference held in 1904 the question of interesting and enlisting the young folks of the farm in the institute work received earnest consideration. Systematic measures are now on foot in several counties of the State to awaken an abiding interest on the part of the young people in the institute work. One method that has been adopted is the awarding of prizes to young people for exhibits of products grown or made by them, these exhibits to be made first at the county fair and later at the institute the following winter.

The support rendered to the institute work by Purdue University is deserving of special mention. The president of the university has served as chairman of the joint committee on institutes during the entire period since the work has been placed in charge of the institution, and the director of the experiment station has also served as a member of the committee. The bills presented against the institute fund by county chairman and institute speakers, aggregating several thousand dollars each year, have been registered and audited by the officers of the university free of charge. In addition to this all the members of the agricultural faculty and several of the general faculty of the university have attended a large number of the institutes and taken an active part, making no charge whatever for their services, altho their duties have been materially increased by this gratuitous work.

The local expenses of the meetings are met by an appropriation of $25, which is apportioned to each county for this purpose. In addition to this, two speakers are assigned by the State whose expenses are met by the general committee. About $1,000 has been annually expended upon the several district institutes and in holding the annual conference of institute officers and workers. The balance of the institute fund is used to pay the salaries of the superintendent and clerks, and to defray the expenses of the superintendent's office, including postage, printing, stationery, traveling expenses, etc.

Some of the results of the institute work are more intelligent and better care of the soil; greater attention to prevent the introduction of noxious weeds; better culture of crops; increased area devoted to clover and leguminous crops; improvement in seed corn; better kept farms; improvement in live stock; greater interest in dairying and horticulture; greater interest and pride in the calling of the farmer; improvement of the rural highways; improvement of rural schools; improvement in home reading; higher appreciation of the natural advantages of Indiana as an agricultural State; and a greater recognition of the necessity and value of agricultural education as a means of continued progress in agriculture.

IOWA.

In the winter of 1870–71 a number of farmers' institutes were held in Iowa, organized by Dr. A. S. Welsh, the president of the Iowa Agricultural College. Among those who were lecturers at these institutes were President Welsh, Professors Jones, Matthews Bessey and Berry, of the faculty of the college. These were the first farmers' institutes held in the State.

The following report by President Welsh to the board of trustees of the college, taken from the College Annual, dated February 1, 1871, giving the work of the institutes for 1870, shows the method that was pursued in conducting the farmers' institute work:

> Many of the trustees will remember that last fall an urgent demand was made outside the institution for a winter session. Such a session, however, was for reasons well known to you found to be impracticable. It is now thought to promise better results to the farmers, that farmers' institutes, somewhat similar in method to the teachers' institutes, should be held by a few of the older members of the faculty in different sections of the State. We propose that each institute shall last five days, and that its program shall consist of lectures for day and evening sessions, on stock breeding and management, fruit culture, farm accounts, and kindred topics. The first farmers' institute is already appointed in Cedar Falls, to open on the 20th instant (December, 1870); the second is to commence on January 3, at Council Bluffs, in response to an earnest invitation from the farmers of that county; and the third will be held in Muscatine, by desire of its citizens; time not fixed. A fourth may be held in Boonesboro or Ames. Now it is desirable that this new experiment should be tried without much expense to the farmers in attendance, and if the trustees should see fit to appropriate a moderate sum for traveling expenses it would, I have no doubt, be wisely expended. Professor Jones, Professor Matthews, and myself will conduct the exercises.

The attitude of the board is shown by the following extract from the action of a committee to which was referred the president's report:

> In regard to the farmers' institutes, without hesitation we entirely coincide with the president's plans, and believe that great good will result therefrom, and most earnestly desire that a sufficient amount may be appropriated to defray the necessary expenses thereof.

The following prospectus was published by the college in February, 1871:

> *Farmers' institutes.*—At least three farmers' institutes will be held in different parts of the State during the winter vacation.
>
> First farmers' institute opens December 19, 1871; second farmers' institute opens January 2, 1872; and third farmers' institute opens January 16, 1872.
>
> These institutes will open on Tuesday evening and continue to Friday evening of the same week.
>
> The sessions during the day will be occupied with lectures and discussions on stock breeding and management, fruits and fruit growing, farm architecture, farm engineering, farm accounts, raising of crops, etc.
>
> Public addresses on subjects connected with agriculture will be given in the evenings.
>
> A farmers' institute may be secured at any locality, in the order of application, by forwarding a written request to the president of the college signed by 50 farmers who desire to attend all the meetings.
>
> It is expected that the current expenses of the lecturers will be paid by those in whose interest the institute is held.

At the beginning of the institute work in Iowa, and for a number of years thereafter, the expenses were borne by local contributions. In 1890–91 the station and agricultural college and the State agricultural society appropriated a small sum to pay the expenses of the college professors and other competent lecturers at these institutes.

The Iowa Improved Stock Breeders' Association, discerning the value of the institute system, took action at an early date to secure recognition and financial aid from the State. In 1889 that association past the following resolution:

> *Resolved*, That we ask the legislature to require all county and district agricultural societies receiving money from the State (for local fairs) to hold farmers' institutes within their territory every winter, and we also ask a yearly appropriation of $5,000 for expenses of such institutes.

This association reiterated the demand for State aid at its sessions in 1890 and 1891. At the latter session the Hon. James Wilson, serving as chairman of the committee to which the measure was referred, reported a resolution favoring legislative action and named as a committee to frame a bill for submission to the general assembly the following gentlemen: Senator B. R. Vale, Henry Wallace, and J. B. Furrow, president of the State Farmers' Alliance. The bill prepared by this committee followed closely the system then in operation in a number of States, providing for a central board and superintendent of institutes under whose direction the money appropriated should be expended. The legislative committee, composed mainly of farmers, adopted a substitute bill which was finally past, and which provided for the holding of county institutes and appropriated $50 to each county for this purpose.

It was stated that the object of such institute should be "the dissemination of practical and scientific knowledge pertaining to agriculture in all its various branches."

This act was amended by the general assembly in 1902, increasing the appropriation for each county institute to $75 per annum, and further providing that each county institute shall be entitled to representation at the annual sessions of the State board of agriculture. Under the operation of this law there has been a steady advancement in the number of institutes and public interest in the annual sessions.

There is no central organization or State superintendent of farmers' institutes in Iowa. The counties act independently in their institute work. In the year 1903–4 institutes were held in 70 of the 99 counties of the State. The attendance for that year is estimated at about 17,700 and the number of sessions at about 350.

KANSAS.

The farmers' institute work in Kansas began in 1868. The honor of organizing the first meeting seems to be divided between the board of regents of the State agricultural college and the Union Agricultural Society, which was organized June 6, 1868. The first officers of this society were: President, J. S. Hougham; vice-president, Elbridge Gale; secretary, R. D. Parker, and treasurer, William Wells. The directors were C. B. Lines, Wabaunsee County; Samuel Cutter, Riley County, and Orville Huntress, Clay County.

This society arranged in its constitution to meet on the second Saturday of each month, and its object was stated to be "to promote, by exhibits and by exchange of opinions and experiences, the pursuits of horticulture, agriculture, and arboriculture."

The Manhattan Standard, in its issue of October 31, 1868, referring to the Union Agricultural Society, printed the following item:

"*Agricultural institute.*—It is proposed to hold an agricultural institute in connection with the Horticultural Society on Saturday, the 14th of November."

In its issue of November 7, 1868, the same paper contained the following item:

"*Farmers' institute.* Arrangements have been made to hold a farmers' institute in connection with the next regular meeting of the Union Agricultural Association. The exercises will occur in the County Hall in Manhattan, November 14, 1868." The subjects to be discust were announced as follows: Tree borers; culture of fruit trees; economy on the farm.

This institute was held according to announcement, as appears from a statement in the Manhattan Standard, December 5, 1868:

"*Farmers' institutes.* The Union Agricultural Society met in the County Hall, Manhattan, November 14, 1868, at 10 a. m., and was called to order by President Hougham. The first business was an address by President Denison, of the agricultural college. His theme was "The Relation of the College to the Agricultural Interests of the State." This was followed by discussion.

The next was a lecture by Professor Mudge on tree borers, followed by discussion. In the afternoon there was an address by Rev. Mr. Gale on fruit-tree culture, followed by a lecture on economy on the farm, by Professor Hougham. This appears to have been the first farmers' institute held in Kansas.

But about the same time that the Union Agricultural Society took action looking to the establishing of farmers' institutes in Kansas the board of regents of the State agricultural college, at Manhattan, took up the same subject. The college records show that at a meeting of the board of regents of the college, June 23, 1868, at which

E. Gale, vice-president of the board, presided, the matter of farmers' institutes was suggested by Mr. Gale, and at the ensuing session the subject was formulated into a set of resolutions presented by Charles Reynolds, a member of the board. The resolutions, after referring to the desirability of extending the benefits of the institution to the people of the State at large, provided that "the president and professors be required to visit the more populous settlements of the State and by free converse, as well as by formal lectures, make known the character and aims of the State agricultural college."

Before adjournment Hon. G. W. Glick, a member of the board of visitors, who had been invited to meet with the board of regents, presented the following resolution:

> *Resolved*, That a system of lecturing on agricultural subjects at this college and in the populous settlements of the several counties of the State should be continued, so that the benefits of farming according to correct agricultural principles may be disseminated throughout the State.

In compliance with this resolution a farmers' institute was appointed for November 20 and 21, 1868, to be held at Wabaunsee, to be addrest by President J. Denison, Professors Mudge and Hougham, Hon. C. B. Lewis, and others. (Manhattan Sentinel, November 14, 1868.)

This same paper, in its issue of November 28, refers to the Wabaunsee institute in the following manner:

> There was a large attendance and the interest of the farmers was manifest. Several topics of practical value were discussed, and altogether this second of the series of institutes in agriculture by the faculty of the agricultural college was a decided success.

An account of the institute held November 14 appeared in the Kansas Farmer for December, 1868, then edited by George T. Anthony, afterwards governor of the State. In commenting upon the institute the editor says: "The idea of agricultural institutes is, we believe, original with the president and professors of our State agricultural college. The initial step in this enterprise was taken Saturday, November 14, by the holding of an institute in the court-house at Manhattan." The same article, in giving an abstract of President Denison's address, reports him as stating that he believed there existed a demand for such concerted action among the tillers of the soil as would be afforded by the system of agricultural institutes there and then inaugurated.

A third institute was held at the agricultural college at Manhattan, beginning January 18, 1869, and continuing thru the 19th, 20th, and 21st. The announcement states that "a number of persons will unite with the faculty in giving lectures." At this institute the following subjects were discust: Cultivation of land; fences; cooperation in farming; gypsum as a fertilizer; potato growing; progress in the world; weeds; small fruits; raising fruit trees; Indian corn; raising hedges and forest trees; cultivating trees; insects injurious to vegetation; birds, their habits and the benefits we receive as well as the injury that is done by them to crops; the dairy.

The Kansas Farmer for February, 1869, under the heading "Agricultural college lectures," gave a ten-column account of this institute, which concluded as follows: "Thus terminated in the most successful manner an experimental effort to inaugurate and popularize a system of agricultural institutes under the auspices of the State agricultural college."

In 1870 a three-day institute was held at the college, beginning January 17. A full report of this is given in the Manhattan Standard for January 22 and 29, 1870. In 1871 a similar institute was held at the college, which was advertised in the Manhattan Nationalist for January 13, and a full report was published in that paper in its issue of January 27.

The next institute was held in 1872 at the agricultural college, with a reported attendance of 428. The Kansas Farmer for February 1, 1872, in its account of the institute, states that "it was originally intended, we believe, to hold these institutes under the auspices of the college faculty in different parts of the State, but this plan seems to have been abandoned for the one of holding these gatherings annually at the college during the winter term." The fifth annual institute was held in 1873. The attendance was referred to by the Kansas Farmer as "surprisingly large." The Nationalist refers to this as "the most profitable and interesting one yet held."

The institute held in 1874 was the last one of this series under the special patronage of the college. Classes were dismissed, and students were expected to attend. The board of regents attended some of the sessions.

Institutes, however, continued to be held under the auspices of the Bluemont Farmers' Club, but were of local character. This club held institutes in nearly, if not quite, all of the years up to and as late as 1888.

The present system of farmers' institutes was begun by President Fairchild in 1881. President Fairchild had been intimately associated with the farmers' institute work in Michigan and thoroly appreciated its value to the farming population. The Industrialist in its issue of November 26, 1881, states that—

> It is proposed to organize a series of annual institutes thru which the State agricultural college and the farmers of the State may work together for the promotion of agriculture. The professors will, under the direction of the board of trustees, take part in six farmers' institutes in as many portions of the State provided sufficient encouragement is given by application from local organizations. The board will endeavor to choose among the applications in such a way as to accommodate the greatest number this winter, with a view to reaching all parts of the State during a series of years. Applications should be sent to President Fairchild at as early a date as possible.

President Fairchild, in an article published in the Industrialist March 25, 1882, speaking of the system of farmers' institutes, states that—

> Since the middle of January members of the faculty have taken part in six such gatherings, besides those held annually, as heretofore, in Manhattan. In this way we have met the prominent farmers of Clay, Cloud, Osage, Barton, Jackson, and Coffey counties. * * * For the next winter it is proposed to select six more counties from among those which apply first and can be readily reached and to hold in them better institutes than the good ones of the first winter—better because experience will help to better methods. The college will furnish, as in the past winter, three or more speakers and pay their expenses, but will insist that each institute make provision for at least half the speakers from among those interested in the immediate locality.

Up to 1890 the expense of farmers' institutes was met by appropriations made by the board of regents from the income fund. The cost varied from $123 to $490 per annum. In 1899 the legislature made an appropriation of $2,000 for each of the next two fiscal years, and this has been repeated by the two legislatures since then. The first two years the amounts expended exceeded the appropriation, while for the other years a balance has reverted to the treasury. These appropriations have greatly increased the number of institutes assisted. The largest numbers were held in the fiscal years ending June 30, 1900, and June 30, 1901, namely, 134 and 156, respectively. These large numbers were made possible by arranging class work so that the members of the farm department were entirely free from teaching duties during the fall months, and speaking tours were arranged for them largely under the patronage of creamery companies. In this way more meetings were held, but they were to a greater extent of the character in which the local population did not contribute to the program excepting by participation in discussions. In the latest years the increase in students, and consequently in the number of classes to be handled, has become a greater burden upon the teaching force, and this has reached a point where the farmers' institute work can not be extended or even maintained without additions to the teaching force. While no requests for institutes have been declined where the people themselves were preparing a program; efforts to extend the work and encourage the organization of institutes have not been made, or at all events to a very slight extent. If the college and station force were of sufficient numbers to permit it, there is no doubt that the institute work might be enormously and rapidly extended, especially if it were transformed into a series of speaking tours in which the people of the localities visited participated only as listeners or as questioners. There can be no doubt, however, that an institute to do the most good must be one which trains and develops the talent of the people of the locality, enabling them to help each other. However capable a speaker from the college may be, he often lacks the knowledge of local conditions necessary to make his advice of the highest value.

The numbers of institutes held from 1881 to 1904 are as follows: 1881–82, 6; 1882–83, 5; 1883–84, 7; 1884–85, 6; 1885–86, 6; 1886–87, 8; 1887–88, 8; 1888–89, 10; 1889–90, 8; 1890–91, 11; 1891–92, 11; 1892–93, 10; 1893–94, 17; 1894–95, 22; 1895–96, 22; 1896–97, 19; 1897–98, 29; 1898–99, 62; 1899–1900, 134; 1900–1901, 156; 1901–2, 102; 1902–3, 88; 1903–4, 58; 1904–5, 55.

KENTUCKY.

The commissioner of agriculture of Kentucky in 1887, in his report to the governor, states "that farmers' institutes are on the increase in Kentucky. These institutes, like those organized by the educators of our youth, are directly in line of rapid and substantial progress."

Previous to 1895 the commissioner of agriculture of Kentucky was appointed by the governor. He was not allowed any assistance whatever in conducting his bureau and only $2,000 was appropriated for all of the expenses of the department, except salaries and the printing of the biennial reports. The $2,000 as well as the salaries and the cost of printing were drawn from the general funds of the State. As a result farmers' institutes as separate organizations were difficult to maintain. The commissioner accordingly was compelled to hold his institutes in connection with the State fair meetings or those of other agricultural and horticultural organizations. The work so far as the department of agriculture was concerned was therefore necessarily conducted under difficulties that limited its extent as well as affected its efficiency.

The first commissioner of agriculture chosen by the people was elected in November, 1895. Under the new constitution the newly-elected commissioner was allowed an appropriation of $13,000 for the running of the department, and an assistant was furnished at a salary of $1,200 a year. All salaries of the department, however, and the cost of printing the biennial reports, as well as all other expenses of the bureau, came out of this fund. Mr. Moore, who was the first commissioner elected by the people, was enabled from this increased appropriation to widen the scope of the work of the department by holding farmers' institutes. Institutes accordingly were held in several of the counties of the State that year and a considerable number of farmers' clubs were organized. The work thus begun would no doubt have proved very fruitful, as the people were just beginning to manifest an interest in it, but during the latter part of that administration there occurred a political upheaval that practically destroyed all the work of institute organization that had been accomplished. The farmers' clubs went to pieces and the farmers of the State generally lost interest in agricultural improvement.

This state of affairs continued up to the beginning of the next administration, September, 1900, when Colonel Nall, the new commissioner, using the remnants of the clubs as a nucleus, began the work of reorganization. Some difficulty was encountered in securing the interest of the people in the movement, but after a good deal of effort more than twenty clubs were organized and the holding of institutes was begun. Some very successful meetings were held in the various counties and they were attended with good results. During the session of the legislature of 1902 the law governing this bureau was changed, but, fortunately, the change did not materially affect the institute work. By this act a labor inspector, with an assistant, were added to the department, as well as the administration of the child-labor law. The salaries of these inspectors were directed to be paid from the annual appropriation of $13,000, but to offset this the legislature had the cost of printing the biennial reports removed from this appropriation and charged to the general fund, thus preserving the amount that had annually been appropriated to the farmers' institute work unimpaired.

The methods employed at present in this State are somewhat different from those of many other States. There is no such thing as a "State farmers' institute" in Kentucky. The method of organization begins with the county club, which is organized under rules laid down by the department of agriculture. No club is recognized with a membership of less than 20, and after its organization the secretary is required to file a list of all of the officers and members of the club with this bureau. A State lecturer and organizer is constantly engaged in forming these clubs. After their organization he explains what is expected of the club and suggests a line of work for it. The club is then in a position to apply for a date for a farmers' institute. It becomes the duty of the club to make out its own local program, sample programs having been furnished by the bureau at Frankfort. This is in order to arouse local interest thruout the community and to bring out and develop local talent. After the local speakers have been assigned the program is forwarded to the State commissioner of agriculture, who adds such other lecturers as he wishes. The experiment station at Lexington aims to send one or more representatives to each institute, and as their lectures are thoroly practical as well as scientific they are appreciated by the farmers and their questions and discussion of the points presented are always interesting and instructive.

For the first time in the history of the department an effort will be made the coming year (1905) to hold meetings in series, using as far as practicable the same corps of special lecturers in each series. The State is much in need of more institutes and is prepared to give greater attention to their development than has been done heretofore. Many farmers are loth to give up antiquated ideas of farming and hesitate about trying new crops even when it is clear that the old crops do not pay, and are slow to take up new and scientific methods notwithstanding the fact that the old methods have proved failures.

While farmers' institute work in this State is comparatively new, the citizens are gradually becoming interested. One noticeable feature is the willingness on the part of the farmers to take an active part in the meetings. Where a few years ago it was difficult to secure local lecturers there now is not a county in the State where a farmers' club has been organized and where the farmers have learned the value of cooperating with the department of agriculture, in which there is experienced any difficulty in securing persons to read papers or make extemporaneous talks at the institutes.

LOUISIANA.

The first successful effort to organize farmers' institutes in Louisiana was made immediately after the creation of the board of institute managers, December 10, 1896. In a report of the bureau of agriculture for December, 1896, the commissioner states:

> At a recent meeting of the bureau of agriculture and immigration it was determined to inaugurate during the year an active system of farmers' institutes. Thomas D. Boyd, president of the Louisiana State University and Agricultural and Mechanical College; W. C. Stubbs, director of the Louisiana experiment stations, and J. G. Lee, commissioner of agriculture and immigration, are named as the board of institute managers, the commissioner being named as institute conductor.

During the following year (1897) 27 institutes were held thruout the parishes of southwest and north Louisiana. These institutes, altho the first ever held in the State, were well received, and much interest was manifested, as is shown by the attendance which amounted to something over 3,000 that year. The teaching in the institutes was performed by a corps of experienced instructors drawn from the University and the Agricultural and Mechancial College, and from the State experiment stations, assisted by some of the most successful farmers. There were also a number of lecturers from other States.

The meetings were strictly agricultural, the papers and discussions being confined as far as possible to matters relating directly to the interests of farming people. The work thus begun under most encouraging and favorable auspices promised from its incipiency to become an important factor in bringing about a change from the old one-crop method that had prevailed to that of diversified agriculture.

The second year of the farmers' institutes was equally encouraging. Twenty-eight were held, and every institute was well attended. In many places where the institutes had planned for but a single day they were continued for two days at the urgent solicitation of the people of the community in which they were held. The legislature from the first responded with considerable generosity by making an appropriation of $1,500 per annum in support of the work, and as it developed in interest and value increased the amount to $2,000 per annum. Bulletins containing the proceedings of the various institutes are annually published and distributed. These publications have been found to be valuable aids in educating the farmers as well as in encouraging them to adopt better methods in cultivation and in increasing their appreciation of the institute work.

That the institute is not a passing fad or mere temporary excitement is evidenced not only by the steady annual increase in attendance, and the frequent calls that come from all parts of the State for the appointment of more meetings, but also by the practical demonstrations which the farmers themselves furnish, exhibited in the numerous instances of the successful growing of a variety of crops thru systematic rotation, in the employment of better methods of culture, and in the planting and growing of more "food" crops for home use.

The outlook for the continued success of the work is very encouraging. The legislature at its next session will in all probability increase the appropriation for institute purposes sufficiently to enable the State director to broaden and extend his institutes so as to carry meetings into all of the parishes of the State.

MAINE.

The first movement looking toward concerted action for the improvement of agriculture in Maine was in 1787, but it was not until 1832 that the industry was recognized by act of assembly framed specially to encourage farm life and work. The act referred to provided for the payment of premiums to the various agricultural societies "for the introducing or improvement of any breed of cattle useful to the State or any tools or implements of husbandry or manufacture, introducing or preserving any valuable trees, shrubs, or plants, or in any way encouraging or advancing any of the departments of agriculture, horticulture, or manufacture."

The leaders of that early period realized not only that agriculture was an important industry, but they also were convinced that the best way of developing it was by encouraging the individual farmers, and thus premiums for superiority in production were awarded by the State. The payment of the premiums, however, were conditioned upon the exhibitor first delivering to the society a statement in writing specifying in detail "the kind and quality of dressing used upon the land, the course pursued in using same, the kind of soil cultivated, with such other facts as may be deemed useful."

These reports by exhibitors were gathered and preserved, and many of them were published in the columns of the Maine Farmer, the agricultural and home paper of the State, founded in 1833 by Ezekiel Holmes, of Winthrop, the first secretary of the board of agriculture and a man of rare insight and profound learning, who devoted his life to arousing love for the farm and a desire for education in agriculture.

Thruout the State these statements were taken up by farmers' clubs, then quite common, and discust by men trained to think for themselves in the hard school of daily experience. The enthusiasm for agriculture then kindled has never been extinguished.

In 1852, chiefly thru the influence of Doctor Holmes, then a member of the legislature, the State board of agriculture was established, but it was not until 1880 that the legislature made provision for the holding of farmers' institutes. The sum appropriated, however, was so small, $1,400 annually, that the work planned could not have been carried forward but for the self-sacrificing labor and devotion of those who literally "went about doing good," with no thought of recompense. These earlier lectures by the leaders constitute to-day the best agricultural literature of the State. Prior to this date summer meetings for farmers had been held and much individual work done, without compensation, so that when the regular institute came the State was ready for the movement, and from the beginning good audiences greeted the speakers.

From the first the secretary of the State board of agriculture has been the captain in command, directing the lines of work by personal contact with the farmers of the State. Both day and evening sessions were planned for, and as the State law requires, at least two institutes have been held yearly in each of the counties of the State. These meetings have gradually grown to be among the most important of any held within our borders.

The annual reports of the board of agriculture from 1855 to 1902, and of the department of agriculture since that date, 5,000 copies of which are distributed yearly among the farmers of Maine, have given those who have preserved the volumes an agricultural library of inestimable value, and also a complete history of the growth of the industry. The papers and addresses which they contain are by the most able and conscientious men of the State, and for breadth of thought, clearness of expression, and spirit of loyalty to the agricultural interests are unsurpassed.

In 1901 a complete change occurred in the administration of the agricultural affairs of the State. The legislature abolished the old board and created a department of agriculture, with a commissioner in charge. The new department was given permanent quarters in the statehouse, the salary of the commissioner was increased from $600 annually to $1,500, and his entire time was expected to be given to the duties of his office. Along with this, the sum appropriated for farmers' institutes was increased to $3,000 per year. For awhile instead of but two institutes being held yearly in each county, as the law prescribed, an attempt was made to multiply the number by holding single sessions in adjoining towns at the same time that the main institute was in progress. This was soon abandoned. The dividing of the lecture force, which this new method required, weakened the central meeting and did not correspondingly aid the other localities visited.

About fifty institutes are held each year. The past few years show an annual increase of over 20 per cent in the attendance, and the year 1904 just closed shows an increase of 10 per cent over any previous year. The general custom has been to employ on the lecture corps one speaker from out of the State and two practical, experienced men, of recognized ability and standing, in the State. These, with the commissioner, constitute the teaching force, the commissioner personally taking charge and directing every session. Institutes are held consecutively, county after county being visited until the entire State has been covered. The dates and subjects to be discust are fixt by the commissioner, after consultation with representative farmers in each locality.

During recent years the Grange in Maine has been growing rapidly, erecting commodious and attractive halls in every part of the State, and devoting itself largely to educational work with special reference to the improvement of rural life and to the general upbuilding of agriculture. The result has been that greater interest is being manifested in the institutes than formerly, and the institute lecturers now find themselves compelled to make more thoro preparation for their work than was necessary in the past, in order that their audiences may be satisfied with the teaching and the high level of the institutes be maintained. Many of the meetings are held in Grange halls. These buildings are all equipped with dining rooms and kitchens. There are also stables for horses, so that man and team are provided for and made comfortable. The lecturer, therefore, at one of these Grange centers is sure to have a comfortable place in which to speak and to have a wide-awake and intelligent audience, prompt to discuss his statements and ready to question.

The interest now manifested by country people in all lines of agricultural production, as stock husbandry, orcharding, small-fruit culture, etc., as well as relating to the subjects of good roads and agricultural education, will require that the institutes be further developed to meet the expanding needs of farmers in these and other respects.

More institutes, better teaching, accompanied by practical demonstration in stable and field, is the demand of the farmer for the years to come.

MARYLAND.

The history of the farmers' institute work in Maryland begins with an organization of farmers effected at Brooke Grove, March 6, 1844, at the residence of George E. Brooke, and known as the Farmers' Club of Sandy Spring. Two farmers, Benjamin Hallowell and Richard T. Bentley, both of Sandy Spring, Montgomery County, imprest with the need of periodical meetings where neighboring farmers might exchange views and report the result of their experience and observation in their farm practise, agreed to invite the farmers of their community to meet for the purpose of forming an association which should hold stated meetings for the discussion of agricultural subjects and operations in which they were interested. The result was the meeting referred to and the organization of the Farmers' Club, with Henry Farquhar as secretary. The membership included the most prominent and successful farmers of that community.

It is remarkable that from 1844, the date of its organization, to 1905 the club has met at the regularly appointed times, with only six omissions. Full minutes, showing the transactions of each meeting, have been faithfully kept during this period of over sixty years. The following constitution and by-laws of this club are unique in being models of brevity and comprehensiveness: "We adopt for our government no rules or regulations other than those which should always prevail in good society."

H. J. Patterson, director of the Maryland Experiment Station, in a paper read before the Vansville Club of Prince George County, quotes the text of a bill by S. D. Coad, of St. Mary County, introduced in the general assembly in 1847, making provision for a State laboratory, and which past that body December 18, 1847. The bill, in prescribing the duties of a chemist, provides, section 5:

> That it shall be his further duty to deliver one public lecture after having given timely notice thereof in each election district in each county, and then to deliver a course of public lectures at each county town and at some central place in Baltimore County, having given also sufficient notice thereof in each election district; and he shall permit the clerk of the levy court, or the commissioners of the tax, as the case may be, to take a copy of such course of lectures to be retained and kept for the use and benefit of the county, and published by said levy court or commissioners of the tax, if to them it shall seem expedient.

In January, 1866, the Enterprise Farmers' Club and in 1872 the Montgomery Farmers' Club were also orgainzed in this same community. With the cooperation and support of these clubs the farmers' convention of Sandy Spring holds annually a meeting at which there are present hundreds of citizens from all parts of the State. These clubs, aided by the influence of the annual convention referred to, have done much for the securing of legislation in aid of the agricultural interests of the State.

It is a disputed question as to which particular club or Grange organization is entitled to the honor of first suggesting the formation of a State department of farmers' institutes, but the credit for having a bill enacted and approved by the governor unquestionably belongs to the Vansville Farmers' Club of Prince George County. This act was past March 27, 1896, and creates a department of farmers' institutes in the Maryland Agricultural College.

When the draft of the law was first discust before the Vansville Club there was a difference of opinion as to the form which it should assume. Mr. George E. Lowrey made a strong plea for the establishing of a department of agriculture for the State and committing the institute work to it. This was opposed by President Silvester, of the Maryland Agricultural College, who maintained that the agricultural interests of the State should be vested in its agricultural college and experiment station.

The act of legislature finally agreed upon and afterwards enacted is substantially as follows:

That one institute shall be held each year in each county of the State and an additional one if deemed necessary and desirable.

That the institutes shall be under the direction of a director appointed by the trustees of the Maryland Agricultural College. The salary of the director is to be fixt and his duties defined by the said board.

That the institute shall be a department of the college and that the salary of the director and the expense of the institutes shall be paid out of the annual appropriation of $3,000, which the act provides.[a]

Altho this act was not approved until March 27, 1896, there was held at Annapolis, January 14, 1896, under the auspices of the Vansville Farmers' Club, an institute which was the first farmers' institute, as that term is now understood, held in the State of Maryland. Since that time the work has expanded until it now extends to every county in the State.

At a meeting of the board of trustees of the Maryland Agricultural College, held June, 1896, William Lee Amoss, of Harford County, Md., who had for nine years acted as secretary for the Harford County Farmers' Convention, an offspring of the Montgomery County Convention, was elected director of farmers' institutes under authority of the act of assembly of March 27, 1896. Mr. Amoss is still director of farmers' institutes for the State.

Farmers' institute work in Maryland has steadily grown in favor, altho at first it was regarded by some of the counties as a doubtful acquisition to the existing system of education. At present the opposition has been overcome and the institutes are welcomed by the farmers as affording a means of instruction that has been found to be of great service in aiding them to a better understanding of their art. The high plane on which the work began has never been lowered, but has been fully maintained, and the movement has secured the active cooperation of the leaders in agriculture in every county of the State.

MASSACHUSETTS.

In telling the story of the farmers' institute movement in Massachusetts justice would not be done to the sterling record of that Commonwealth in this line of work if the account did not go back of the actual establishment of the farmers' institutes, denominated as such, and pay some attention to the first stirrings of thought and awakening of effort among the farmers and agricultural organizations of the State.

At the first meeting of the trustees of the Massachusetts Society for Promoting Agriculture, the fourth agricultural society to be organized in this country, held August 3, 1792, a vote was past recommending that members of the society in different parts of the State should meet from time to time, inviting their neighbors to join them, for consultation and discussions relating to agriculture, with a view to the gathering of information useful in the work of the society. Presumably such meetings were held, altho the early records, from the nature of the case, are meager in the extreme, and I can find no confirmation of that opinion. Certain it is that here was the germ of the farmers' institute movement and there are but few, if any, earlier recorded expressions of opinion or recommendations for action that look toward meetings for agricultural discussion.

An interesting secondary phase in the development of the movement for agricultural instruction by lectures and discussions is that of the lectures or addresses on agricultural topics which were delivered before the agricultural societies at their annual exhibitions. The first printed lecture of which record has been found was that delivered before the Massachusetts Society for Promoting Agriculture, at the Brighton Cattle Show, October 13, 1818, by J. Lowell, which is about twenty pages in length and very agricultural in its nature. Many such addresses of later date are found on record, and while these meetings were not called farmers' institutes it was perhaps because that term had not yet been hit upon as a means of designation.

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[a] See U. S. Dept. Agr., Office of Experiment Stations Bul. 135 (Revised), p. 18.

The Massachusetts State Board of Agriculture was established in April, 1852, and at its third meeting, held on September 7 of that year, a committee was appointed on the best means of promoting agriculture in the State by means of public lectures. At a subsequent meeting, held December 1, 1852, this committee submitted a report favoring the calling of the attention of the people to the importance of having lectures on agriculture form a part of the course of all lyceums and similar associations in the rural districts of the Commonwealth. This report was accepted and a committee appointed, which later, thru the agricultural papers, issued a notice calling the attention of those interested in agriculture to the subject.

At the next meeting of the board, January 12, 1853, Doctor Hitchcock, of Amherst College, having been previously requested to present his views on some topic connected with the improvement of agriculture, read a paper on "Farmers' institutes." In this paper he said that he had attended teachers' institutes and had been imprest with the influence which they exert and suggested that we should have farmers' institutes as well, outlining some subjects which they might very profitably consider.

The matter seems to have been dropt there for the time, but in 1859 a committee was appointed to consider and report upon the propriety of instituting meetings similar to teachers' institutes.

In the autumn of 1863 the first three-day meeting of the State board of agriculture for lectures and discussions was held, and these meetings have been a yearly feature of the work of this board down to the present day. They fill the place to a certain degree which is occupied in many States by the annual or "round-up" institute, so called, but have no connection with the farmers' institutes themselves, which are held by the agricultural societies and the expenses of which are paid from other appropriations. The lectures and discussions at these meetings are printed in the annual report of the board, and every effort is made to have speakers of the highest rank and authority on their various subjects.

The next action of the board was at the annual meeting in 1878, when it was voted that societies receiving bounty from the Commonwealth be requested to arrange one or more farmers' institutes each year within their limits, and that they be informed that the board will render all the assistance in their power to make such institutes interesting and instructive.

The Hingham Agricultural and Horticultural Society had already begun to hold such meetings, the first being held on November 17, 1858, the subject being "The present condition of agriculture in Hingham and the best means of awakening a greater interest in the same." It would seem as if such a discussion might be of benefit in many sections even in this year of the twentieth century.

On February 6, 1879, the previous vote of the board was amended so that the societies were "required" instead of "requested" to hold these institutes, and the number was changed from one to three each. These early meetings were addrest by members of the board, whose traveling and necessary expenses were paid by the State, no appropriation being available for the payment of institute workers until 1888. It appears from the statements of the representatives of the societies the following year that every society in the State had held at least three institutes, while many had greatly exceeded the required number, but they appear to have been allowed to lapse, for in 1887 it was moved that the rule requiring them to be held be enforced. This motion was adopted after discussion and a committee appointed to consider the whole subject and report at the county meeting of the board in December.

This committee subsequently submitted a lengthy report, the most important feature of which was the recommendation that the secretary of the board ask of the State an appropriation of $1,000, to be expended under the permission of the statute giving the secretary of the board of agriculture authority to employ lecturers and agents to speak to the farmers and organize farmers' clubs. The general court of the following year granted an appropriation of $1,000 for this purpose, thus placing the institute work on a stable basis. From that time to the present day the work has continued, increasing in importance and broadening in scope from year to year, and in no year has any society been allowed to evade the requirement of the board that at least three farmers' institutes shall be held.

The appropriation for the work has been increased from time to time as circumstances seemed to call for it, and the legislature was moved with the spirit of liberality toward the farming interests until it is now fixt at the sum of $2,700 per annum. Only a part of this appropriation is used for the institute work, however, it being made for the "dissemination of useful information in agriculture," and a considerable portion of it being devoted to the issuing of crop reports, special bulletins, nature leaflets, etc. Generally speaking, about $1,800 is expended in institute work. When the appropriation was materially increased two years ago, it was hoped that a greater number of institutes might be held, but a new contract with the State printers increased the cost of printing by about 20 per cent, which left the appropriation available for institute work at about the former rate, so that while the work has not decreased in importance it has not been broadened or increased to the degree that was planned for.

The farmers' institutes of Massachusetts, as above indicated, are based on the agricultural societies and held by them, these societies being required to pay the expenses of advertising the meetings and to pay for the hall, where payment is necessary, and for heating and lighting the same. The State thru the board of agriculture pays for the compensation and expenses of the speaker, $10 having been fixt as compensation for each lecture. Many of the societies hold all-day meetings, with two sessions and two lectures, the second one sometimes from a local speaker and sometimes by the speaker furnished by the State, the speaker donating his services or the society giving him extra compensation, as the kindness of the speaker or the financial condition of the society may allow.

The institutes are not entirely confined to the agricultural societies, the secretary of the board being empowered to give institutes to other associations of an agricultural nature where the section is not properly covered by one of the incorporated agricultural societies, of which power he avails himself to a considerable extent, so that no section of the State where meetings of this character are desired need go unprovided for.

Upward of 100 institutes are held each year, with an average attendance of about 100 persons at each meeting. Probably there is no State in the Union where so many meetings are held in proportion to the area of the State, tho that assertion can not be made absolute without a more careful investigation. The system seems the one best adapted to the needs of the people of this State, as it combines home rule with central supervision. A list of speakers, with their subjects, is printed each year, from which the societies are expected to make their selections, no speaker not upon that list being engaged for a meeting until the secretary of the board is fully satisfied as to his fitness for the work. On this list are the professors at the agricultural colleges and the workers at the experiment stations of this and neighboring States, together with practical farmers of proven excellence as speakers and instructors. No person is admitted to the list until the committee in charge of the work is satisfied as to his or her fitness to address such meetings, both as to subject-matter and method of delivery.

Whether the future will bring a closer departmental control of the institutes is a question for future consideration. There are certain obvious advantages in more rigid control, but such control would call for largely increased appropriations and might possibly also result in a falling off of interest by offending the conservatism of the farmers who have a sturdy independence which calls for a large voice in the management of all matters connected with their interests.

MICHIGAN.

The farmers' institute movement started in Michigan in 1875, as a result of conference of members of the faculty of the Michigan Agricultural College. President T. C. Abbot, Robert C. Kedzie, W. J. Beal, A. J. Cook, and R. C. Carpenter were among those present. Believing that it would be to the interest both of the college and of the farmers to establish closer relations and to come together for the discussion of topics of mutual interest, a request was made of the State board of agriculture for an appropriation to pay for the expenses of such a series of meetings. The appropriation was granted and the first meetings were held at Allegan and Romeo in January, 1876.

The speakers were supplied from the faculty of the college, and the attendance and interest were so satisfactory that similar meetings have been held each year since that date. For some twelve years the number of regular institutes numbered only six annually, and each member of the college faculty was expected to attend two institutes. The calls for institutes increased until it was determined to hold a larger number each year, and about 1891 the number was increased to twenty-two. Previous to that time the work of arranging institutes has been attended to by the secretary of the college and by members of the faculty. The preliminary correspondence was carried on by the secretary, and after the places for the meetings had been determined each of the institutes was placed in the hands of a member of the college faculty, whose duty it became to "work up" the meeting. As a rule, the places were visited, and at a preliminary meeting a local committee was appointed to take charge of the arrangements for the meeting. Topics were selected for the State speakers, and local talent enlisted to furnish one or more papers for each session, as well as music and recitations. The conductor also looked after the itinerary of the State speakers and saw that hotel accommodations were secured and that proper local arrangements were made.

When the number of institutes was increased the general charge of the work was placed in the hands of A. C. Glidden, who was at the time a member of the State board of agriculture. The interest in institute work increased until in 1895 the State made an appropriation of $5,000 annually for farmers' institutes, and the State board of agriculture deemed it wise to appoint a special superintendent of institutes and selected Kenyon L. Butterfield for the purpose. Mr. Butterfield was also given charge of the college-extension work and advertising. The law under which the appropriation was made provided that a two-day institute should be held in each of the counties which requested one and which organized an institute society. It also gave the board of agriculture authority to hold a number of one-day institutes. As originally past, the law provided that in case a county institute society did not care to accept the speakers furnished by the board of agriculture an allowance of $25 should be made for the payment of the expenses of an institute to be held in the county. This was repealed by the next legislature, however, and at the present time only the per diem and traveling expenses of the State speakers who attend the institutes are paid.

When the number of institutes was increased, the faculty of the college was no longer able to carry on the institute work without assistance, especially as in 1895, the college year, which previously provided for a winter vacation, was changed so that the long vacation came in the summer. It therefore became necessary to secure a considerable number of speakers in addition to the assistance that could be furnished by the members of the faculty. For the most part, the speakers chosen were successful farmers and fruit growers. In order that he might be sure that the speakers carried out in practise what they advocated in their addresses, the superintendent visited them in their homes and looked into the methods used by them. It was also found possible to enlist in the work a number of the faculty of the State University and normal schools. For the first year the per diem of the regular speakers was $3, in addition to railroad and hotel bills, but one year later the sum was increased to $4 per day for those who acted as conductors of institutes, and it has since been increased to $5 after a speaker has spent one season in institute work. Contrary to the custom in many other States, no one who is in the regular employ of the State of Michigan can draw a per diem for institute work.

The increased appropriation made it possible to hold some 50 institutes annually, in addition to a four-day round-up. Several one-day institutes were also held. These were attended by but one speaker and were frequently arranged in connection with a farmers' picnic during the summer months. Finally, in 1899, the annual appropriation was increased to $7,500, and this made it possible to still further increase the number of one-day institutes. In 1903–4 some 70 two-day institutes and 221 one-day meetings were held. For the most part the two-day institutes were held in some town near the center of the county or at some point that could be readily reached by the railroads. In some counties it has been thought advisable to hold a meeting at the same point year after year, but in others it has been found better to change the meeting point each year. The one-day institutes are held in the smaller towns, frequently in a Grange hall or schoolhouse, and as they are usually held two or three weeks in advance of the two-day institute, they act as feeders for it, and serve to bring out many persons who would not be able to attend the two-day meeting.

For the two-day institutes the smallest number of persons furnished is three, one of whom is a woman, who speaks in the general sessions of the meeting upon topics relating to poultry raising, butter making, education, and other topics that would be of general interest, and who acts as conductor and speaks at a special woman's section, which is generally held the second afternoon of the institute. These women's sections have met with much favor, and in very few cases does it happen that when they have once been held in a county it is voted to discontinue them. It is found advisable in some instances, and especially in counties in the southern part of the State, to furnish lecturers upon topics relating to good roads, farm law, veterinary science, education, and other topics that can not be treated by the average institute worker.

Unlike the custom in many of the States, an endeavor is made to make the people feel that it is "their" institute. The local arrangements are made by the executive officers of the county institute society, and the county secretary attends to securing local talent for the program and looks after the advertising. As a rule, the time is about equally divided between the State and local speakers, and ample opportunity is afforded after each paper for questions and discussion.

The interest in institute work in Michigan is on the increase; and altho the funds will only permit the holding of an average of 3 one-day institutes in each county, a large number of counties ask for from 8 to 10, and others would hold from 12 to 20 could a State speaker be furnished them. The success of an institute in almost any of the counties depends to a large extent on the thoroness with which it has been advertised and "worked up." As this is in the hands of the county secretary, it can be said that the success of the institutes in the given county will depend to a large extent upon the efficiency of the man selected to act as secretary of the institute society for that county.

At the close of the institute season a report is published giving the organization of the various institute societies and a report of the work for the year. The proceedings of the round-up institute are usually published in full, and frequently space is given for printing some of the papers read at county institutes. These reports are mailed to all who have become members of the county institute societies, as well as to libraries, newspapers, and to farmers who may apply for them.

It may be further stated that, altho they were not called farmers' institutes, the Michigan legislature in 1861 past a law providing for lecturers upon farm topics to others than the students of the agricultural college. Michigan was also the first to make an appropriation for farmers' institutes, as well as the first to establish a permanent institute system. It is also the only State that has held farmers' institutes continuously for the past twenty-eight years.

MINNESOTA.

Farmers' institutes were not held in the State under the auspices of any governing board nor were they supported by State funds until the year 1886. Prior to that date the efforts that had been made to bring the farmers in touch with a higher agricultural education and with improved methods of farming had not been successful in any marked degree. They looked at such an education and at such methods with suspicion and kept themselves and their sons at what they considered a safe distance from it. The agricultural branch of the university languished. Overshadowed by the luxuriance of the other branches, it could scarcely be seen. The university was virtually without agricultural students. The farmers were not only not in sympathy with such an institution, but a majority of them were hostile to it. In a word, a great gulf existed between them and the higher education offered to their sons by the university. Before anything could be done this gulf must be bridged over. The necessity for such a bridge had much to do with the origination of the farmers' institute in Minnesota.

Hon. H. E. Hoard, of Montevideo, was among the first to agitate in favor of farmers' institutes in the State. In 1883 the annual meeting of the Northwestern Dairyman's Association was held in Mankato. It was at that meeting that Mr. Hoard, A. H. Reid, of Glencoe, and P. B. Nettleton, of Montevideo, became imbued with the idea that farmers' meetings of some kind should be called occasionally in various parts of the State for the discussion of topics relating to the farm. Meetings were held at Montevideo and Glencoe, respectively, in 1884, 1885, and 1886. A bill was introduced into the legislature of 1885 to appropriate $5,000 annually to sustain the institutes, but it failed to pass. In 1886 a series of farmers' institutes was inaugurated by the agricultural committee of the board of regents. Profs. E. Porter and O. C. Gregg were the chief speakers at these meetings. As the students had failed to attend the agricultural classes at the university, Professor Porter conceived the idea of going out among the farmers and holding meetings in their midst. It was in support of this idea that an appropriation of $1,000 was made by the agricultural committee of the university board of regents to defray the expenses of the thirty-one institutes held in 1886. Many of these meetings were in connection with county fairs, a most unsuitable place for holding institutes, as has since been proved by experience. Meanwhile Mr. Gregg had been accustomed to hold what may be termed little institutes of his own at certain fairs which he chanced to attend. They were convened in the open air, somewhere near the cattle sheds. The theme was dairying, and more especially the dairy cow. Ex-Governor Pillsbury, endeavoring to solve the problem of interesting the farmers in higher education in agriculture, heard of this work and after a conference with Mr. Gregg, requested his assistance in the work of establishing farmers' institutes in the State.

In February, 1887, Hon. H. E. Hoard, at that time a State senator, introduced into the legislature a bill providing for the continuance and maintenance of the farmers' institute. The bill was championed in the house by the Hon. W. R. Estes, of Madelia. The bill, as finally past, provided that $7,500 per annum should be devoted to farmers' institute work.

In 1889 the annual appropriation for institutes was increased to $10,000; in 1895 to $12,500; later to $13,500; then to $16,500; and in 1904 it was made $18,000 per year.

The members of the first board of control were H. H. Sibley, president board of regents; D. L. Kiehle, secretary board of regents; W. R. Merriam, president State Agricultural Society; W. H. Denny, secretary State Agricultural Society; S. M. Emery, president State Dairy Association; Frank D. Holmes, secretary State Dairy

Association; E. H. Atwood, president State Farmers' Alliance; Eric Olson, secretary State Farmers' Alliance; Wyman Elliott, president State Horticultural Society.

The membership of the board was subsequently modified, so that it now consists of three members chosen from the State board of regents, and of the presiding officers of the State Agricultural Society, of the State Horticultural Society, and of the State Dairy Association. The regents on the board are appointed by the president of the board of regents. This board of administration appoints the superintendent and assistant superintendent of institutes from year to year and defines their duties. They map out the course and location of the meetings that shall be held during the season. The details of this work are left with the superintendent.

In April, 1887, Mr. Gregg was chosen superintendent and was given entire charge of the work. The only restrictions put upon him were to counsel in a general way with the board of control then established, as to when the institutes would be held, to report progress at stated times, and to account in the customary way for the money used.

In determining where institutes shall be held due regard is had, first, to the needs of the locality; second, to convenience and economy in money and time when traveling from one institute to another; third, to the response on the part of the farmers at previous institutes that have been held there; and, fourth, to the urgency of the requests for institutes that have been made by letter or otherwise to the proper parties. These requests should be addrest to the superintendent or to the chairman of the board of administration.

The winter circuit of the institutes usually begins with December and ends with March. The summer circuit commonly begins in the closing days of May and terminates with July. As there are more than eighty counties in the State, it is not possible, as at present conducted, to hold an institute in each county every year.

The superintendent maps out, for submission to the board of administration, the institute circuit for the season and arranges the details of the institute meetings. He edits the Institute Annual, signs all checks for institute expenses, and reports to the board of administration from time to time the condition and progress of the institute work.

The institutes are advertised by means of posters, handbills, and fly sheets. Prior to the issuing of these an advance agent is sent out to visit the various localities desiring institutes. If the way is clear for the locating of the institute at a given point, the advance agent selects a suitable hall and secures the cooperation of the business men of the locality in advertising the meetings.

The institute teaching force is selected with great care. Only those who have shown capacity to instruct are permitted to lecture. Charts, models, a cooking outfit, dairy apparatus, portable blackboard, etc., for illustrative purposes are provided by the superintendent.

The sessions of the winter institutes were formerly continued for two days. This has been modified until now by far the largest number are one-day institutes. The summer meetings usually begin about May 20 and extend thru June. These are all one-day meetings and are made up of two sessions.

A feature of the institute in Minnesota is the use of the living animal on the platform for illustrative purposes in lecturing upon animal-husbandry topics. In summer these demonstrations are frequently held in the street.

The attendance at the Minnesota meetings has always been very large. As many as 1,200 persons have been present in a single day. The total number for the year 1904, present at the 154 institutes held was over 46,000.

A great deal of attention has been paid by the institute board to giving instruction in the breeding, feeding, and handling of dairy herds, as well as in the manufacture of dairy products.

In 1890 a cooking school was made an adjunct of the institute work. Good cooking is now taught in the Minnesota institutes as regularly as good farming. Charts, showing the composition of foods, are used by the demonstrators to show how balanced food rations may be constructed.

At every institute held in Minnesota there is at least one address given on the work of the college of agriculture of the State. The college is thus brought to the attention of farming people in a way that interests and informs them and enables them to become personally acquainted with many of the professors who are engaged in giving instruction in agriculture in the institution. The work of the agricultural experiment station is likewise referred to and the main features of its operations explained.

The Institute Annual is an important educational feature of the Minnesota institutes. It is a book of about 300 pages, composed of addresses by the institute lecturers and articles contributed by experts upon various agricultural subjects. The book is edited by the superintendent of institutes and copies are distributed at the institute meetings of the succeeding season. The edition numbers 30,000.

MISSISSIPPI.

The first appropriation for farmers' institute work in Mississippi was made in 1900, when the legislature appropriated $1,000 for the years 1900 and 1901. When this appropriation was made the institute work was well established. In 1899, 28 institutes were held, in 1895, 18 institutes were held, and in 1897, 15. Prior to this time only 4 to 5 institutes were held each year, beginning in 1884.

Where an institute was held without any other attraction—such, for example, as a barbecue or picnic—50 to 100 farmers were usually in attendance, but in some cases, especially for the first institute, as many as 400 or 500 people would attend. As an average result each institute reached about 75 or 80 farmers, and where some social feature was associated with the meeting the total attendance was from 200 to 500 and, in a few cases, perhaps 1,000. The few institutes that were held from 1884 to 1888 were usually accompanied by some social feature, such as a barbecue or picnic. They were largely attended, and the expenses of such speakers as went from the college were paid out of college funds,

After the establishment of the experiment station in 1888 station funds were used to defray the expenses incurred for holding institutes until the legislature made the first appropriation, referred to above.

Up to 1904 the legislature has made three appropriations for holding farmers' institutes, covering a period of six years. The second appropriation was $3,000 and the third $6,000. The latter appropriation is still available for the work of the next two seasons.

With increased appropriations more institutes have been held each season, and the average attendance has increased to some extent. In 1903, 107 institutes were held, and the estimated attendance was 11,326. Forty institutes were held in 1901 and 58 in 1902.

At first the institutes were very often continued for three days. Two-day institutes, however, were most common until 1898, since which time one-day meetings have been regarded as better, tho a number of communities continue to express a desire for two-day sessions. Most of the institutes have been held during July and August. The work is under the immediate direction of the president of the Agricultural and Mechanical College.

Institute work in Mississippi has accomplished great good. It is causing the farmer to think, observe, and, to some extent, to read. It has brought the college, the station, and the farmers closer together, so that they know each other better. As the attendance at the institutes has increased so the number of students at the college has multiplied, and the bulletin mailing list has grown larger.

MISSOURI.

The farmers' institute as an organized educational institution, as well as all other organized agencies for the advancement of agricultural development and education in Missouri, are so closely identified with and have been so largely promoted and developed by the State board of agriculture that in recording the history of farmers' institutes in this State it is necessary to consider the board of agriculture and the institute organization together.

The first State agricultural society receiving patronage from the State was incorporated by the legislature by an act approved February 24, 1853.[a] In the same year an agricultural fair was held by this society at Boonville, and the most prominent feature of this fair was a public address by Hon. Uriah Wright, of St. Louis, in which he made a master argument in favor of agricultural education. Mr. Wright's address shows that the importance of special education for the farmer was at least thought of in Missouri more than forty years ago and at a time when much of the State was yet a vast wilderness.

During the winter of 1864–65 the legislature incorporated the Missouri State Board of Agriculture. The board was organized under this act at its first meeting held March 13, 1865. The work of the board for the first few years of its existence consisted mainly in exploiting the resources of the State and in gathering useful information on crops, improved breeds of live stock, new inventions of farm machinery, etc. This information was published in the annual report and distributed among the farmers of the State and no doubt had a considerable influence in opening up the way for the future work of the board.

The annual meetings of the board held for the purpose of transacting routine business soon developed into what was practically a State institute meeting. At these meetings the most intelligent and successful farmers and prominent scientists would meet with the board, and papers were read and addresses delivered on current farm topics in as able a manner, considering the state of progress of science at that time, as are the subjects now handled at one of our present-day State institute meetings.

The first effort of the board of agriculture toward the establishment of farmers' institute meetings was made at the annual meeting held in St. Louis, September 9, 1869.[b] A resolution drawn by Norman J. Colman was unanimously adopted at that meeting pledging the support of the members of the board to the organization of institute work and promising their assistance and attendance as far as practicable whenever possible. No meetings were held, however, under this resolution, for lack of available funds.

The second and successful move toward the establishment of organized institute work was made at the annual meeting of the board of agriculture, held November 1, 1882,[c] by Prof. J. W. Sanborn, who at the time was filling the position of secretary of the board of agriculture as well as that of dean of the agricultural college. Upon the suggestion of Professor Sanborn a committee was appointed to report on the organization of farmers' institutes. The committee after deliberation reported resolutions, which were adopted by the board, setting forth the desirability of holding farmers' institute meetings during the coming winter and requesting the secretary of the board to notify the farming communities thru the press of the desire of the board to cooperate with them in holding institutes and that the board would defray the expenses, except that the counties must furnish hall for the meeting and heat and light it free of expense to the board. The secretary was also requested to arrange with not less than three nor more than five members of the board for the delivering of addresses upon some farm topic.

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[a] First Ann. Rpt. Bd. Agr., 1865.

[b] Ann. Rpt. Bd. Agr., 1869.

[c] Ann. Rpt. Bd. Agr., 1882.

This was undoubtedly the beginning of a new era for the board, for from this time on we find that its work was extended and it came into favor with the farmers of the State. Under the authority of the above regulations the first regularly organized farmers' institute meeting was held at Independence, Mo., on December 18 and 19, 1882. The subjects discust at this meeting were small fruits, stock feeding, corn culture, the double tree, butter production, farm experiments at the college farm, animal growth and nutrition, sorghum as a source of sugar, and pork pointers.

For the season of 1883–84 two meetings were held, and from that time on the number was yearly increased until during the season of 1888–89 fourteen meetings were held. These meetings were conducted by the secretary of the board of agriculture, assisted by members of the board and successful farmers who could be induced to take part in the work, and also members of the faculty of the agricultural college. No salaries were paid the lecturers, but only traveling and hotel expenses, which expense was paid out of the very small contingent fund of the board of agriculture. Up to this date the largest amount of funds used in one year in institute work was about $500 expended on the meetings for the season of 1888–89. The first appropriation made by the legislature explicitly for use in institute work was during the session of 1891, and during the same session the duties of the board of agriculture were greatly enlarged and more liberal appropriations given than had hitherto been made for the support of the board. The total appropriations, however, were yet very modest considering the extent of territory and the scope of the work. The biennial appropriations made for institute work from the first appropriation in 1891 until the present time are as follows: 1891–92, $10,000; 1893–94, $8,000; 1895–96, $6,000; 1897–98, $6,000; 1899–1900, $4,000; 1901–2, $8,000; 1903–4, $10,000. Total for fourteen years, $52,000.

Out of the above appropriations all expenses for advertising, printing, postage, per diem, and expenses of lecturers have been paid.

That the work is making a reasonably good progress is shown by the following statements for the season of 1903–4. There were 147 meetings held with a total attendance of 30,220. Twenty-eight lecturers were on the institute staff, 13 of whom were furnished by the State agricultural college and whose expenses only were paid, while 15 others were employed at a stipulated per diem and expenses.

Thru all these years the progress has been slow but permanent. A great many obstacles have been in the way. The greatest hindrance perhaps has been (1) a lack of information among some of the farmers as to the real object of the institute work, and (2) their prejudices against "book farming" caused, no doubt, by impracticable methods advocated by some so-called agricultural writers and teachers. These hindrances, however, are no longer in our way, for thru the practical work that is being done by the institute lecturer hundreds of farmers have been benefited and are now earnest in their efforts to promote the work. The only difficulties we find in our way now are first to secure sufficient funds and second to find plenty of competent help.

MONTANA.

Farmers' institute meetings in Montana started practically with the organization of the agricultural college and experiment station, the first institute meetings being held during the year 1893, the year the college was organized. Meetings were held this year in some 49 places, scattered in most of the counties of the State. The experiment station staff, of which at that time Prof. S. M. Emery was director, were the principal speakers at the meetings.

These meetings were conducted with the understanding that the various districts visited raise funds sufficient to pay the expenses of the institute workers. The lecturers, being mainly members of the college and experiment station staffs, served without extra compensation. The large interest taken in these meetings under the circumstances is worthy of note and shows that the Montana farmers and business men were alive to the importance of the work.

From the first year the railroads of the State gave free transportation to the institute workers. After that this favor was withdrawn, and this large addition to the expense cut down the number of meetings at the smaller settlements for succeeding years. A few meetings were held, however, in various parts of the State nearly every year up to the enactment of the present farmers' institute law, which was past during the winter of 1901. The law is as follows:

SECTION 1. The board of administration of farmers' institutes as provided for in this act shall consist as follows: The governor of the State and the director of the Montana Experiment Station, both of whom shall be ex officio members, and the president of the following named organizations, the Montana Wool Growers' Association, the Montana Live Stock Association, the Montana Horticultural Society, the Montana Agricultural Association, and the Montana Dairymen's Association, when these last two shall have been duly organized. Members of such board of administration shall be designated the "directors of the Montana farmers' institutes," and shall be authorized to hold such institutes for the instruction of the citizens of this State in the various branches of agriculture, and shall prescribe such rules and regulations as they may deem best for organizing and conducting the same. Such institutes shall be held at least once in each county in each year and at such times and places as the directors may designate. The directors may employ an agent or agents to perform such work in organizing and conducting said institutes as they may deem best. The course of instruction at such institutes shall be so arranged as to present to those in attendance the results of the recent investigations in theoretical and practical agriculture.

SEC. 2. For the purpose mentioned in this act the directors may use such sum of money as they may deem proper, not exceeding the sum of $2,000 in any one year, and such amount is hereby annually appropriated for that purpose out of the moneys in the State treasury not otherwise appropriated. Each institute held under the authority of this act shall be entitled to the sum of not exceeding $50 from the amount appropriated under this act.

The institutes are placed under the direction of the agricultural organizations of the State, and thru the directors of the experiment station are kept in touch with the scientific investigations of the station. In the organization of the board the director of the station was made secretary of the board and later superintendent of the farmers' institutes, with immediate charge of the work over the State. During the first and second year under the law it was found that sufficient funds had not been provided to meet the needs of the work, and so but a part of the State was covered during this time. An annual report of nearly 300 pages was gotten out, however, and the interest in the work increased, so that the law was amended during the winter of 1903 and the amount of funds appropriated increased to $4,000 per year.

While the station and college staff has been the main dependence of the work, yet a large number of practical farmers have generously contributed freely of their time in visiting various parts of the State to help at these meetings. Some fifteen or twenty persons have signified their willingness to help. This will make it possible to extend and broaden the scope of the work.

The State has been divided into districts, and the people in the various localities have been encouraged to organize local farmers' institutes. Some ten to twelve such organizations are now in existence, and a live interest is being taken in the meetings. During the past year every county in the State has been visited, and a marked increase in attendance and interest was shown over the previous year. It is believed that the work has now a firm place in the educational forces of the State and in the confidence of the people.

NEBRASKA.

The farmers' institute movement in Nebraska began, so far as records are obtainable, with meetings held at Kearney and Gibbon, Buffalo County, as early as 1877. These meetings were attended by Profs. S. R. Thompson and H. C. Culbertson, from the university, on invitation of the local institute manager. Other institutes were held at later dates without regularity, and no record of the officers in charge or evidence of a permanent organization can be found.

A farmers' institute was held in Nemaha County February 7, 1882. Mr. W. F. Wright was elected president and Mr. Benton Aldrich secretary. Mr. Wright had met Prof. S. R. Thompson at Lincoln to talk over the benefits to be derived from such a meeting, and the above-mentioned date was selected. The meeting was attended by S. R. Thompson, professor of agriculture, and H. C. Culbertson, professor of horticulture. The Hon. R. W. Furnas, secretary of the State board of agriculture, was present at this meeting, together with a large number of men and women who have since been prominent in Nemaha and Johnson county institutes. This meeting was held 20 miles from the nearest railroad station, and the organization formed in 1882 is still active.

In October, 1882, a second organization of the same nature was formed at Tecumseh, Johnson County, adjacent to Nemaha, with J. W. Hosic president and W. R. Harris secretary. This organization performed exactly the same work as that done by the farmers' institute. It continued until February, 1896, when it was merged into the Johnson County Horticultural and Agricultural Society for one year, being reorganized January 27, 1897, under the name of the Johnson County Farmers' Institute, which organization still continues. This organization has held annual or more frequent meetings since 1882, holding in 1905 a four-day institute with an extensive corn show, a good-roads day, and with several sessions of the institute in charge of the women's branch of the association.

On December 27, 1884, there was a meeting of the Lancaster Agricultural Society, and the record of this meeting shows that Prof. C. E. Bessey was present and addrest the society in relation to holding a county farmers' institute. Professor Bessey said that heretofore these institutes had been held under the auspices of the professors of the agricultural college, but he thought that it would be better for the county agricultural society to hold them or assume the control of them. The professors would attend and give lectures and do whatever they could to make such institutes a success. At the close of Professor Bessey's talk a committee was appointed to consider this matter, which named the first Saturday after New Year's as the date for holding the first institute. A series of these meetings followed. They were reported in the papers under the title of "Farmers' Club Meetings," and this organization finally divided into the North and South Lancaster Farmers' Clubs, which have continued their organizations to date.

In 1887 Professor of Agriculture H. H. Wing read a paper before the Nebraska Dairymen's Association on "The Benefit of Farmers' Institutes." This paper indicates a general interest thruout different sections of the State in the farmers' institute movement, which resulted in the formation of a number of institute organizations. This paper recites the fact that at least four such institutes were held in 1887, entirely by the efforts of farmers in their several localities.

Somewhat later, perhaps in 1888, Dr. Bessey says:

> When I was acting chancellor of the university, I took the matter up with Governor Furnas and we planned a series of farmers' institutes to be held in different portions of the State. He volunteered to attend as many as he could; Mr. Bassett did the same. Mr. Stephens of Crete, Mr. Youngers of Geneva, Mr. Dinsmore and others volunteered, and we held a good many institutes beginning with the winter of 1888–89. The plan was that the locality should pay the expense of those who attended. As far as possible we all secured transportation and simply asked the people of the locality to see that we did not have to pay hotel bills. Where the people failed to cover our expenses we bore them ourselves. This work went on with increasing success for a number of years, up to the time when Prof. F. W. Taylor was appointed to look after the matter. Prof. C. L. Ingersoll was active in this work from 1891 to 1894.

In 1889 a three-day farmers' institute was held at Brokenbow, Custer County, January 22, 23, and 24, reported in the annual report of the Nebraska State Board of Agriculture, 1888.

As a result of this agitation, the University of Nebraska, in April, 1896, appointed Prof. F. W. Taylor, then professor of horticulture, superintendent of farmers' institutes, and in conjunction with the several agricultural societies of the State an organization was perfected by which assistance was given local organizations in the holding of farmers' institutes. Among the societies which thus assisted thru the efforts of their officers were the State Board of Agriculture, the State Horticultural Society, the State Dairymen's Association, the State Poultry Association, the Improved Live Stock Breeders' Association, and the State Bee Keepers' Association. "Small contributions from each of these organizations constituted a fund for incidental expenses. Each association furnished speakers, who attended institutes upon request without any compensation and sometimes paying their incidental expenses en route. The railroads in the State provided free transportation for speakers who were required to travel to fill institute appointments."

The first legislative appropriation was made in 1897, $3,000 for the biennium being appropriated by the State legislature to pay the expenses of farmers' institute work, which fund was placed in charge of the University of Nebraska. In 1901 this fund was increased to $8,000 for the biennium, and in 1903 it was further increased to $12,000 for the biennium, which rate still continues.

For the season of 1899–1900 51 institutes were held in 33 counties, reaching from 25,000 to 30,000 farmers, at an expenditure of $1,593, practically all transportation for institute speakers being furnished by the several railroads along which institutes were held. Thirty-eight different speakers were sent out by the central office, all speakers from the university staff being without expense to the institute fund.

The season of 1900–1901 opened at Somerset, August 20, 1900, and closed at Thayer, August 8, 1901. Sixty institutes were held in 46 counties, 21 of these institutes being one-day meetings of two or three sessions, and 39 institutes being two-day meetings holding five regular sessions. The regular institute force consisted of 20 speakers, of which 7 were regular members of the experiment station staff, the balance being farmers and institute speakers not connected with the university. The cost of these institutes was kept within $1,500 appropriated for institute purposes exclusive of the salary of the superintendent and of the members of the station staff, who received no compensation from the farmers' institute fund. The attendance for the year was probably greater than for the previous year, since a larger number of institutes were held, but no exact record was kept to determine the number of persons attending these meetings.

The season of 1901–2 began October 1, 1901, and closed March 29, 1902. Eighty-six institutes were held in 62 counties. The appropriation for this biennium had been increased to $4,000 per year, and $3,882.69 was expended during the first year of the biennium. Twenty-seven institute speakers were employed, 11 of which were connected with the experiment station.

The institute season of 1902–3 commenced at Dorsey, December 2, 1902, and closed at Amelia June 19, 1903. Sixty-seven institutes were held in 43 different counties at a cost of $4,000, only $500 of which was paid for superintendence, the speakers from the experiment station, who this year made up about one-third of the working force, serving without compensation other than actual expenses.

The farmers' institute season of 1903–4 began November 23, 1903, and closed March 24, 1904. Forty-three one-day institutes and 49 two-day institutes were held, with a total of 330 sessions. The total attendance was 26,000, figured according to methods advised by the Farmers' Institute Specialist of the United States Department of Agriculture. Institutes were held in 57 counties.

The State appropriation had been increased to $6,000 per year at the beginning of the season 1903. Ten men connected with the experiment station did institute work. Fourteen other lecturers were employed by the State, these giving their entire time during the institute season.

The season of 1904–5 began November 18, 1904, and closed March 30, 1905. One hundred and fifty institutes were held, of which 88 were one-day meetings, 56 were two-day meetings, and 6 were more than two days. Thirty-eight speakers were on the regular force, of which 18 were connected with the experiment station or the university, and 20 were employed from outside the university. Institutes were held in 68 counties. Average number of speakers at each institute, 3. Eighty-two days' time was given by university men to this work and 463 days by other institute speakers. Four hundred and eighty sessions were held, with an average of 140 people at each session. Sixty-seven thousand, two hundred and forty-one people attended regular farmers' institutes. In addition to this, 41,486 people attended the various pure-seed specials in the State and listened to lectures by members of the experiment station force upon seed corn, seed potatoes, and crops adapted to the western portion of the State. Two thousand people were in attendance at Organized Agriculture, January 16–21, inclusive, which was virtually a round-up institute session altho held under the auspices of the State board of agriculture and associated agricultural societies in connection with the annual meeting of that board. Altho but $12,000 had been appropriated for the biennium, the expenses of this large number of institutes somewhat exceeded the balance of the appropriation, the deficiency being provided for by the payment of a part of the salary of the superintendent and assistant superintendent for the last quarter by the university from other than institute funds.

During the seasons of 1901–2 and 1902–3 such notable farmers' institute speakers as Henry Wallace, of Wallaces' Farmer, M. F. Greeley, of South Dakota, and Mrs. Bertha D. Laws, of Minnesota, took part in the work. Joseph E. Wing assisted in institute work during the seasons of 1902–3, 1903–4, and 1904–5. H. P. Miller, of Ohio, assisted in institute work during the season of 1902–3; D. Ward King during the seasons of 1902–3, 1903–4, and 1904–5. Prof. P. G. Holden, of Ames, Iowa, gave two or three lectures on the selection of seed corn before the farmers' institutes in February, 1902, starting the seed-corn movement in this State.

The Nebraska system combines local and central organizations, no institute being held except on request, the community bearing a part of the expenses, generally amounting to hall rent, local advertising, and local entertainment of speakers at hotels. For the season of 1904–5, 65 out of 150 institute points reported their local expense to be $1,129.23, or an average of $17.37 each. This is probably too high for the average local expense of institute points, especially where court-houses or free hall rent is secured.

Institute dates are made at least six weeks in advance, and the institutes are arranged in series covering at least one week, the dates overlapping each other, so that a speaker fills his appointment and goes on to the next point, not necessarily remaining until the close of the institute.

The subjects of soil tillage, rotation of crops, and varieties adapted to a given locality are made prominent. Alfalfa growing and feeding is a leading subject in most localities in the State. The breeding and selection of seed corn has been made prominent for the last two years. Many exhibits of corn are judged by the corn specialist on the institute force. A number of corn contests have been carried on under institute management. At some institute points the judging of live stock is a part of the program. The subject of feeding is one of paramount importance and is nearly always discust in the corn-belt area. Regular speakers have been employed to discuss the care and management of poultry, the rearing of horses, the care and management of swine, the subject of soil fertility and crop rotations, and the subject of home making. Lady speakers are used, but practically no independent women's sessions are held, except at institutes of more than two days' duration.

Local organizations have a president, a secretary, and treasurer, and a local committee to look after expenses and program.

The central office prints about 50 posters, sends out special notices to from 50 to 100 farmers by postal card, lists being furnished by the local secretaries, sends notices of the institutes to local papers, and endeavors to stimulate local interest by making suggestions regarding methods of holding a successful institute.

No round-up institute is held, on account of the large and popular meetings held by Organized Agriculture at the school of agriculture and the experiment station the third week in January each year. All of the societies for the promotion of different lines of agriculture meet at this time. January 16–21, 1905, these societies held 31 different sessions, with a total attendance exceeding 2,000, and with a program containing many notable men connected with the development of agriculture in other States. A report of this meeting is to be found in the annual report of the Nebraska State Board of Agriculture.

The farmers' institute movement in the State has always been materially assisted by the various railroads, which furnish transportation for farmers' institute speakers upon request of the central office. The transportation thus received amounts to about $2,000 per annum if purchased at current rates.

In addition to assisting the farmers' institute movement, the railroads during the season of 1905 ran special pure-seed trains over several thousand miles of railroad, reaching 41,886 people along their several lines.

The director of the experiment station is superintendent of farmers' institutes, having in charge only the general features of the work. The superintendent of the experiment substation at North Platte, Nebr., Mr. W. P. Snyder, is assistant superintendent of institutes in charge of all the details of institute work. The great increase in the number and interest in farmers' institutes for the season of 1904–5 is due to his personal efforts and energy in promoting this work. It is apparent that the farmers' institute work has become so large in Nebraska that it can not be properly carried on without the continuous time and energy of a superintendent being given to this work.

The legislature appropriated $12,000 for farmers' institutes for the biennium, which became available April, 1905. For the first time this appropriation is drawn on the general fund of the State and is not charged against the university appropriation, altho it remains under control of the regents.

The legislature also past a bill which became operative July 1, 1905, authorizing the board of county commissioners of any county to defray the local expenses connected with farmers' institutes in said county under conditions which they might prescribe.

NEVADA.

The first farmers' institute in Nevada was held December 13 and 14, 1901, at Elko, under the direction of the staff of the Nevada Agricultural Experiment Station. Besides the members of the staff of the experiment station there were present also, as lecturers, Miss Kate Bardenwerper, of the department of domestic science, and J. M. Wilson, of the University of California. Dr. W. R. Dennis, Government stock inspector, was also on the program of speakers. The opening address was given by George S. Brown. C. B. Henderson delivered an address on agricultural colleges. Both of these lectures were of exceptional value.

The importance of having the first institute meeting a success was appreciated by the members of the experiment station. The weather was quite cold, and there was fear that it would prove unfavorable to attendance. Thanks largely to the efforts of Regent W. W. Booher, of the university, the institute was fully as good as could have been expected. Among the subjects discust were: The composition of feeds; The San José scale and the codling moth; how to prevent the spread of infectious cattle diseases; the value of domestic science in education; what man has accomplished with plants and animals; the alfalfa cutworm; irrigation; beneficial bacteria; home dairying; methods of stock inspection; and nature study in home and school.

There were about forty farmers in attendance at the various sessions of the institute. The lectures upon domestic science, given by Miss Bardenwerper, were attended by about sixty ladies from Elko and vicinity. The evening meetings were composed of mixt audiences, numbering about one hundred and twenty-five persons. At the close of the institute the members of the station staff felt gratified at the interest manifested and were confident that they had begun a work that would increase in interest and beneficial effects thruout the years to come.

A committee, consisting of Z. T. Hardesty, Thomas Hunter, George Russell, George S. Brown, and William Smiley, made up a report of the meeting expressive of their appreciation of what had been undertaken, congratulating the experiment station staff and the teaching force of the university upon the excellent work that they had accomplished.

During the winter of 1902–3 institutes were held at Elko, Lovelock, and Gardnerville. The lecture force was composed of members of the agricultural experiment station staff under the leadership of the vice-director.

Four institute sessions were held at Elko, and about forty people were in regular attendance during the day, while the evening session numbered about one hundred. The interest manifested was all that could be desired, and the lectures were highly appreciated. At Lovelock three sessions were held, with an attendance of about eighty persons. At Gardnerville three sessions were also held, but the interest manifested was not as satisfactory as at the other two points. The attendance averaged about sixty persons.

Encouraged by their experience in holding farmers' institutes during the previous two years, the experiment station staff planned to hold institute meetings during the winter of 1903–4 in nine different sections of the State. Somewhat to their disappointment, only four places made application for meetings—Elko, Glendale, Huffakers, and Franktown. Institutes were held at all of these points with quite encouraging results. The topics discust were dairying, irrigation, injurious insects, diseases of animals, stock judging, how to grow hothouse plants, and how to cook and sew. Three of the institutes were one-day and the one held at Elko was a two-day institute. The lectures were given by the members of the station staff, except that Miss Bardenwerper, of the agricultural and mechanical college, gave a number of lectures on domestic science. The advertising was by means of newspapers and handbills, notice being given of the institutes from two to four weeks in advance.

The rich mines that are being discovered in the southern part of the State are adding thousands to its population each year. This means increased demand for agricultural products of all kinds. The institute is endeavoring to introduce general farming among the ranchmen and thus provide for supplying the demand in the home markets for agricultural products.

Agriculture in Nevada is, for the most part, in its elementary stage. The soil is still productive and the farmers and ranchers, as a rule, have not yet come to realize the need of giving special attention to the scientific side of their occupation. The institute, it is believed, will gradually develop increased interest in advanced agriculture and bring about a better appreciation of the work of the university and of the experiment station in their efforts to advance the agricultural interests of the State.

NEW HAMPSHIRE.

The public statutes of New Hampshire require the secretary of the board of agriculture "to make arrangements for giving public notice of, and, if possible, personally attend, the farmers' meetings authorized by the board." Under this general authority farmers' institutes have been organized and conducted.

The first organized agricultural society in the State of which we have an account originated in the county of Rockingham as early as 1814. We find a record on the journals of the legislature of that year, when a charter was granted. It probably had its central point at the then important town of Chester, or possibly at Exeter. A little later

Cheshire and Rockingham counties formed societies. In 1817 a small appropriation of $100 each was made by the legislature to encourage the two societies. Hillsboro and Strafford counties each organized and received charters in 1817. Grafton and Coos quickly followed. In 1819 and 1820 each county in the State had helped to form agricultural societies, held fairs, and received aid from the State. Up to 1820 the appropriation varied from $100 to $300 each, and in all $3,000 had been expended by the State.

In accordance with the recommendation of Governor Bell in 1820 a board of agriculture was created by the State, consisting of a president and a delegate from each society. In 1821 a board of twelve members was organized and William Badger was chosen president and Matthew Harvey secretary. Only one report was ever written and that largely by Rev. Humphrey Moore, of Milford, in 1822.

About 1850 the New Hampshire State Agricultural Society was formed, its purpose being to improve the agriculture of the State, and for ten years it published reports at the expense of the State and held agricultural fairs that were well attended. Such men as Daniel Webster, Hon. Edward Everett, and Marshall P. Wilder were orators on those occasions.

It was not until August 23, 1870, that both branches of the legislature by unanimous vote created the State board of agriculture, composed, as it is to-day, of one member from each of the ten counties. The governor and council appointed the following members: Merrimac County, Moses Humphrey, of Concord; Belknap County, Thomas J. Whipple, of Laconia; Hillsboro County, James O. Adams, of Manchester; Cheshire County, Sampson W. Buffum, of Winchester; Carroll County, W. H. H. Mason, of Moultonboro; Grafton County, Luther B. Hoskins, of Lyman; Strafford County, Charles Jones, of Milton; Rockingham County, Joseph F. Lawrence, of Epping; Coos County, Nathan R. Perkins, of Jefferson; Sullivan County, Edward H. Brown, of Croydon. The first meeting was held Tuesday, August 23, 1870, and Hon. Moses Humphrey was chosen chairman and James O. Adams secretary.

The first public meeting or farmers' institute held by the State board was at Concord, November 29 and 30, 1870. A number of other meetings followed at various points in the State during the winter, and for several years such gatherings held by the State board of agriculture were called "public meetings," but they did not differ materially from the meetings which are now generally known as farmers' institutes. In announcing these meetings, the term "institutes" was not used in New Hampshire until 1887. Since that date institutes have been held each year in the different counties and reports of their proceedings published annually.

During 1904 18 institutes were held, composed of 38 sessions; 3,400 people were in attendance, and 16 lecturers were upon the State corps of instructors, four of whom were from the faculty of the agricultural college and from the staff of the agricultural experiment station. The total expense was $1,588, all of which was appropriated by the State board of agriculture from the general funds received from the State for institute purposes. Local arrangements for holding institutes are made by the secretary of the board with Grange organizations, farmers' clubs, and agricultural and horticultural societies. The reports of the proceedings are annually published. During 1904, 2,000 copies of these reports were distributed.

NEW JERSEY.

The New Jersey State Board of Agriculture was organized and established by a law enacted in 1872. This law, with its later amendments, made provision for auxiliary organizations, such as county boards of agriculture, granges, and local farmers' clubs.

The last-named organizations have been in the habit of holding a number of meetings each year for the discussion of matters relating to the improvement of farm stock, cultivation of the soil, application of manure, commercial fertilizers (their composition and use), fruit production, etc.

Thus these meetings assumed, to a limited degree, something of the institute character. The original law provided for lectures before the State board at its annual or other meetings, but it did not empower the executive committee to provide for lectures in the counties under the auspices of the State board of agriculture.

In 1890 Secretary Dye secured an amendment to the old law, which was approved March 31 of that year, empowering the executive committee to employ lecturers in the counties of the State. Under that enactment and from that date to the present a series of farmers' institutes for each year has been arranged and conducted thruout the State, beginning, usually, in the month of November and closing in February. These annual series include the yearly meeting of the State board, which occurs about the middle of January and covers a period of three days with two evening sessions.

While lectures on agricultural topics had been given in a number of the counties at the county boards of agriculture and farmers' club meetings as early as 1875, the organized lecture work under the name of farmers' institutes and under State supervision was not inaugurated until 1890, as stated above.

The development of this work has been gradual, but prejudices in some localities against this sort of agricultural instruction had to be met and overcome. The true purpose and meaning of the institute must be clearly set forth and understood and its possible value to the farmer, his family, and his business demonstrated beyond a reasonable doubt. These results have been largely attained, but further development is needful, not only in New Jersey but elsewhere, if the institute is to meet the new, ever-recurring questions as they appear.

In New Jersey the scientific and practical are placed side by side on the institute platform. The theories and teachings of the scientist that have been applied in practise are given to the farmer with his methods and results.

The farmers' institutes in New Jersey consist of three, four, and five sessions, covering one and two days in a given locality, as occasion seems to demand. It is the aim to hold at least one institute in each agricultural county, but in some counties three and occasionally four have been held.

The amount of money available from the State for this work approximates $2,000 annually. This is expended for printing and lectures. Halls for meetings must be furnished free by the locality requesting an institute.

While the aim is to secure from time to time the best workers from adjacent States, the State agricultural college and experiment station force is also freely drawn on. In addition to these are a number of progressive, thinking farmers thruout the State who study their business and can state with clearness their experience on whatever line of farming they may be following.

By such a selection of speakers it is found practicable to treat most subjects of importance with a comprehensiveness not otherwise possible.

There is not much machinery. The advertising is by postal card and press notice first, later by a program of subjects, directed to such persons as are specially desired to attend the meeting. Two weeks before the institute large posters are put up in the neighborhood by the local committee.

The plan is to reach as many farmers as possible with the money at the disposal of the board, and to adapt the addresses and discussions to such matters as are of chief interest to the farmers in localities visited.

Altho New Jersey is not large territorially, her agricultural industries vary greatly. She requires a larger list of subjects and addresses on more varied lines than any other area of similar size.

There is no printed report of the institute proceedings. Occasionally arrangements are made to have an institute speaker recast his institute addresses into a single lecture and deliver it at the annual State meeting. This address is printed in the annual report of the State board of agriculture and has wide circulation.

While the old branches of agriculture are discust, attention is also given to special industries in the different localities. Some general questions of great importance to farmers have been made leading topics in the institutes—the question of soils, their origin, constituents, requirements, adaptation to different crops, etc.; then, too, the subject of forage crops for the dairy, how to produce, their feeding value, when and how to harvest, etc.; the cost of dairying as now conducted with a view to exposing defects in breeding, feeding, and general management, where they may be found to exist, in hope of showing a way to increase the profits.

The seed has taken root and already fruit appears. The desire is that the work may be progressive, practical, and helpful.

NEW MEXICO.

The first institute was held January 2–4, 1896, at the agricultural college, Mesilla Park, under the auspices of the agricultural experiment station staff, with Director S. P. McCrea as chairman. Morning and afternoon sessions were fully occupied with papers and discussions by the station staff and other local speakers. Four of the papers presented were by ladies. There was an average attendance of twenty-five at each session.

A second and similar institute was held at the college January 4–6, 1897. Director C. T. Jordan presided. The average attendance at each session was about thirty.

No more institutes were held until the spring of 1903, after the election of Luther Foster as director of the station.

During January, February, and March, 1903, three one-day institutes of two sessions each were held at Las Cruces, under the auspices of a local committee. The first was devoted to alfalfa and irrigation by pumping; the second to fruit growing, small farming, and truck gardening; and the third to live stock. Director Foster presided at each of these and the papers were presented and discust by members of the station staff and other local speakers.

On March 3, 1903, an institute, with afternoon and evening sessions, was held at Carlsbad. Three members of the experiment station staff were in attendance and presented papers, the other speakers being local. This institute was held under the auspices of a local committee.

On March 4 and 5 the same members of the station staff attended an institute of five sessions at Roswell. These meetings had been arranged for by the local horticultural society.

An institute was held at Cloudcroft, on the summit of the Sacramento Mountains, on October 30 and 31, 1903. The station was represented by Director Foster and two other members of the staff, and the El Paso (Tex.) Chamber of Commerce was also represented by its president and two members. There were three sessions at which papers were presented and discust by the members of the station staff, representatives of the chamber of commerce, and local speakers. Among the topics discust, roads and markets received especial attention. A local institute was organized.

Three one-day institutes, of two sessions each, were held at Las Cruces during January and February, 1904, under the direction of the Mesilla Valley Chamber of Commerce. All members of the station staff participated and a number of other local speakers. At one of these institutes the Spanish language only was used.

There have been no special appropriations for institute work and the expenses of the station men engaged in this work have been paid out of the funds of the institution. It is hoped that the next legislature will make a special appropriation for institute work, so that it can be extended and placed on a permanent basis.

NEW YORK.

The farmers' institutes in New York State as now organized grew out of the demand among the old farmers' clubs, more than a dozen of which were organized over one hundred years ago, for speakers who were posted on the science of agriculture. For something over fifty years such speakers had been furnished by the State agricultural society, and since the establishment of the college of agriculture at Cornell University in 1868 and the establishment of the State agricultural experiment station at Geneva a few years later the workers at these two institutions have been heavily called upon.

The first move toward the establishment of the present system of institutes was begun in 1885, when Prof. I. P. Roberts, of Cornell University, and Mr. J. S. Woodward, of Lockport, decided that it was possible to hold a meeting of farmers from all parts of the State to consider and discuss subjects of vital interest to them. After consultation with President Adams, of Cornell University, such a meeting was called to be held in Morrill Hall February 16, 17, and 18, 1886. Both Professor Roberts and Mr. Woodward were tireless in their efforts to advertise this meeting thoroly and make it a success, and the result far exceeded their most sanguine expectations. Over 100 names appeared on the register of persons attending the institute, not only from New York, but from adjoining States, and at most of the sessions between 200 and 300 people were present, so that after the first session the meeting had to adjourn to Library Hall, in Ithaca. The meeting consisted of 6 sessions and 18 addresses, "some of which were longer than the management expected," which seriously interfered with the time desired for discussion, altho the audience entered into the spirit of the meeting and, so far as time allowed, the subjects were discust very freely. At the close of the meeting all declared that the first institute in New York State was a success, and it was decided that such a meeting "should be held every year."

A more important resolution adopted, however, was one asking the New York State Agricultural Society, which was then the center around which all agricultural work in the State rotated, "to undertake the work of holding a limited number of farmers' institutes the next winter, and, in case they refused, to petition the legislature for a State department of agriculture to carry on this work."

Another important resolution past at this meeting was in regard to the establishment by law of a State board of agriculture, similar to such boards in other States, and a committee of ten was appointed to consider this subject. This idea, however, was never accepted by the State legislature, as New York's policy is to concentrate responsibility in one central head instead of in boards, the wisdom of which has clearly been demonstrated since the establishment of the department of agriculture in 1893.

When the question of their undertaking to hold farmers' institutes was first presented to the State agricultural society, a large number of the most influential members were strongly opposed to attempting the experiment. After a long and strenuous session, however, thru the zealous efforts of a few who saw the possibilities of the institute movement, the majority decided to make the trial, and at a meeting of the executive board held in Utica in September, 1886, it was decided to hold at least three institutes that winter, and $1,050 was appropriated from the funds of the society for this purpose. A committee consisting of James McCann, president of the society; T. S. Harison, secretary; Maj. Henry E. Alvord, and J. S. Woodward was appointed to look after this work.

At the annual meeting of the society in 1887, largely because of the strong advocacy of the institute work and his untiring efforts to make these meetings a success, J. S. Woodward was elected secretary, and from that time until 1890 was practically director of farmers' institutes in New York State, acting under the direction of an institute committee. To him more than to any other one man is due the great success of these early institute meetings.

After careful planning the institute committee found that they could hold five institutes during the winter of 1887 with the money at their disposal. All these meetings were very largely attended and great interest was shown in the addresses and discussions. At the first one, at Lockport, farmers from the entire western portion of the State were present, while the other meetings drew from as large a territory.

At this time the aid of Josiah K. Brown, the first dairy commissioner in New York State, was of untold value. Thru the organization of the dairy department local interest was awakened and a close connection between this department and the institutes gave them a standing with the State administrators, which was especially valuable when the question of direct appropriations came up. Among others who should be mentioned as lending their encouragement at this time are James McCann, of Elmira; Hezekiah Bowen, of Medina; F. D. Curtis, of Charlton, who perhaps did as much as any other man to popularize the meetings with the masses; Prof. I. P. Roberts, of Cornell University; Dr. E. Lewis Sturtevant, who was then head of the State experiment station at Geneva; Maj. Henry E. Alvord, who was at that time located at Houghton farm, in Orange County; John J. Thomas, of Union Springs; W. Judson Smith and E. A. Powell, of Syracuse, beside many others who were connected with the State experiment station and the college of agriculture, as well as agricultural workers from adjoining States. The influence and ability of these men had much to do in laying the foundation of the present success.

The great demand for meetings in all parts of the State and the great success of this first series led the agricultural society to petition the legislature for an appropriation to carry on this work. The legislature saw the reasonableness of the request, and in March, 1887, past the Wemple bill, appropriating "$6,000 to be used by the New York State Agricultural Society in holding farmers' institutes in various parts of the State." This was the first State appropriation for farmers' institutes in New York, and it enabled the society to hold 20 institutes during the winter of 1887-88 and about 40 the following year.

As the institutes became better known and more widely distributed over the State more farmers realized the benefit to be derived from them, and it was soon found that the $6,000 appropriated was wholly inadequate to carry on the work, and the legislature of 1890 increased the appropriation to $10,000. In 1892 it was again increased to $15,000 and in 1898 to $20,000. Altho the demands upon the director have increased continually and a larger number of applications are received each year, no request for an increased appropriation has been asked for, altho the number of meetings could be doubled and held successfully.

In January, 1891, Mr. Woodward's health broke under the strain and he was obliged to give up the institute work. The agricultural society selected George T. Powell to have charge of the meetings in his place. Mr. Powell carried on the work most satisfactorily until the organization of the State department of agriculture in 1893. During his term as director about 100 institutes were held each year. He introduced many attractive features, among them being special horse-breeders' meetings, which were largely attended. The subject of introducing the study of natural sciences as applied to agriculture in our public schools had a prominent place on the programs and was widely discust. In many places it was not received graciously, and the change in the attitude of people toward this line of work is very marked.

In April, 1893, Governor Flower signed what is known as "the agricultural law," which created a State department of agriculture, with a commissioner of agriculture appointed by the governor at its head, this taking the place of the State dairy department and to a very great extent bringing all of the agricultural work of the State under the management of one man. Under the provisions of this law the institutes, which had heretofore been in charge of the State agricultural society, were taken from it and placed in the department of agriculture. the law providing that the "commissioner of agriculture may appoint a director of farmers' institutes." There was also an item in the appropriation bill providing "that the funds should be paid out on the audit of the commissioner of agriculture." While the wisdom of making this change was questioned at the time, results have shown that the State's action was wise.

Under the provisions of this law, in February, 1893, Fred. C. Schraub, then commissioner of agriculture, appointed George A. Smith, who was one of the State cheese inspectors and who had been a very acceptable lecturer at the institutes upon dairy subjects, as director of institutes, and he filled the office for three years. During Mr. Smith's term of office the number of meetings was largely increased thru holding what are known as "lap-over" meetings, the force being divided between two institutes held in towns easy of access. While this system allows the holding of many more meetings, it is not as successful as it appears on its face, from the fact that the speakers do not get in close enough touch with the audiences and are overworked to such an extent that they are unable to do their best.

In 1896 C. A. Wieting appointed F. E. Dawley, the present director. Mr. Dawley had been connected with the institute work since 1889, and was thoroly familiar with the agriculture of the various sections of the State. He had made a close study of the soils and crops in the different counties, and with his large acquaintance was able to place speakers and subjects very acceptably. He inaugurated a system of advertising, furnishing not only printed programs, but attractive colored posters, and sent out bulletins calling attention to the institute work and to the subjects under discussion. He took particular pains to interest the women who were in attendance and organized a corps of women speakers. The various farmers' organizations of the State were interested as they never had been before, and the officers of the various organizations were brought together and made acquainted. Many petty strifes were adjusted, as these men came to realize that they were all interested in the betterment of the State's agriculture, and a very close union of the State's agricultural interests has resulted. The institutes have greatly benefited from all this and the attendance and interest increased.

Thru lectures on our common school system a renewed interest has been awakened in our rural schools, and the assistance of the State department of public instruction has been asked and granted to such an extent that at nearly every institute held during the winter of 1903–4 a representative of this department has been present and addrest the meeting on school subjects. In many instances the school children have been invited in and the speakers have attempted to make their remarks interesting to them, touching upon bird, animal, and vegetable life in such terms as are readily understood.

Some ten years ago an effort was made to interest the farmers in good roads, but the speakers selected were not acceptable and the movement probably received a setback from their radical recommendations. Under Mr. Dawley's directorship this subject has again been taken up and at nearly every meeting is advocated and discust. The speakers are made thoroly familiar with road laws and the results in sections where they have been in operation and the antagonism to the good-road movement is reduced to a minimum. The State engineer's office has furnished a speaker at many of the meetings, who has proved very acceptable.

The use of the stereopticon has been developed to a very great extent for the evening lectures and has been a most successful educational feature.

Nowhere has the poultry interest been so thoroly advocated as in New York, a speaker on this subject having been in attendance at practically every meeting held since 1894, and the great advance in this industry in the State shows the result.

The present director has taken advantage of the strength of all the agricultural organizations in the State to increase the attendance at the institutes, greatly to the benefit of both the organizations and the meetings. For some reason or other many of these organizations were at low ebb in 1896. The annual meeting of the State Dairymen's Association of the winter before was so poorly attended that it was held in the parlor of a hotel. The next winter the director furnished speakers, which gave one of the best dairy programs rendered at any institute held in the East, and the attendance was about 300. Every effort has been made to make this program attractive up to the present time, until last winter over 1,400 people were present at the meeting. The various horticultural, poultry, and bee-keepers' societies have been assisted in the same way with marked success. Special poultry institutes are held in sections where the interest warrants it, four having been held the past winter, while seven special bee-keepers' institutes were held in counties where this industry is carried on. In certain sections of the State the institutes deal almost entirely with dairy subjects, in another section with horticultural subjects, while in another they will treat of market gardening and the growing of vegetables.

The demand by the farmers for experts and specialists along these different lines is increasing each year, and it is probable that many more special meetings will be held the coming winter than were held last year. The present director, F. E. Dawley, aims to secure the best men available for institute lecturers, and does not hesitate to drop a man immediately if he proves incompetent, irrespective of the influence behind him. The director is thoroly posted as to the needs of each community, and sends as conductors of the institutes men who are also familiar with the local conditions and have sound scientific knowledge and can impart that knowledge in a pleasing manner. The different local requirements have been almost universally met the past winter and remarkably few complaints have been heard. As a rule the same speakers are asked for year after year.

One of the newer features of institute work inaugurated by Mr. Dawley are the so-called "normal institutes," which are held at the beginning of the season. Their purpose is to bring all the workers together before they begin their work for the year to compare notes and to become better acquainted, to give them accurate information on agricultural subjects, and to bring them in direct contact with teachers and professors of recognized authority along their special lines. The discussions form an important part of the program at each session. The first meetings of this character were held in 1899 at Cornell University on November 13 and at the State experiment station at Geneva on November 14 and 15. Similar meetings have been held each year since for one day at Cornell and one day at the State experiment station. In the fall of 1903, however, Mr. Dawley made arrangements with L. H. Bailey, of the agricultural college, and W. H. Jordan, of the State experiment station, whereby a regular course of instruction in the form of lectures could be given and the "normal institutes" be a week of regular college work for the institute force. The professors of the agricultural college and of the State experiment station entered heartily into the plan and spent a great amount of time in carefully arranging their lectures and preparing outlines for each member of the class. The latest scientific information relating to the various branches of agriculture was presented and full discussions followed each lecture. The only regret was that the time was so limited that the work had to be gone over very hurriedly. Forty State workers were in regular attendance, while visitors were present from the District of Columbia, Minnesota, Ohio, Wyoming, and Canada.

The accompanying table gives, as nearly as can be ascertained, the number of farmers' institutes which have been held each year from 1887 to 1903. It will be seen that in 1897 a change was made in the method of reporting the number of institutes, those for a full year, from January to January, being given instead of the number for a season. The growth of the institutes in interest and popularity has been constant, and since about 1890 over 1,000 applications have been received each year, while not more than 300 meetings could be held. During the season of 1902–3 312 meetings were held, and in the season of 1903–4 267 meetings, at an average cost of $54. The average total attendance for the winter has been 64,347 and the total number of persons present has exceeded 130,000.

Farmers' institutes in New York State.

Year.	Number.	Director.	Under supervision of—	Appropriation.
1886	1		Cornell University	
1887	5	J. S. Woodward	New York Agricultural Society	$1,050
1887-88	20	do	do	6,000
1888-89	37	do	do	6,000
1889-90	60	do	do	10,000
1890-91	100	George T. Powell	do	10,000
1891-92	105	do	do	10,000
1892-93	150	do	do	15,000
1893-94	145	George A. Smith	State department of agriculture	15,000
1894-95	277	do	do	15,000
1895-96	275	do	do	15,000
1896-97	242	F. E. Dawley	do	15,000
1897	227	do	do	15,000
1898	257	do	do	20,000
1899	254	do	do	20,000
1900	296	do	do	20,000
1901	299	do	do	20,000
1902	250	do	do	20,000
1903	312	do	do	20,000

NORTH CAROLINA.

The legislature of North Carolina first recognized farmers' institutes in 1887 in the law concerning the board of agriculture. Section 5 of this law is as follows:

> The said board shall cooperate and aid in the formation of farmers' institutes in all the counties in the State and shall send the commissioner of agriculture, the director of the experiment station, the teachers in the agricultural college, and some other representatives from their body to assist in holding these institutes at least once in every two years in every county in the State, in order to instruct the people in improved methods of farming and to ascertain the wants and necessities of the various farming neighborhoods.

There is no very clear record at hand showing what was done under this law that year and the following years, 1888 and 1889, but that a few institutes were held is known.

The College of Agriculture and Mechanic Arts was organized in the fall of 1889. Since it was impracticable for the professors to attend institutes during term time, it came to be the rule that the institutes should be held during the summer vacation and at the comparatively leisure time on the farms between the completion of the cultivation of the crops and their harvesting.

In July and August, 1890, the first vacation after the organization of the college, the then commissioner of agriculture, John Robinson, planned a series of two-day institutes embracing ten counties in the western and southwestern parts of the State. The idea was then new to the farmers, and the advertising of the meetings was defective, so that with a single exception the audiences were small; but in each county interest was excited in the work, and thereafter applications for institutes came in, not only from the counties visited but from many others as well.

There being nearly one hundred counties in the State, it has been impracticable for the commissioner to fully comply with the law, which requires an institute to be held in each county at least once in two years. In fact, there are a few counties in which no institute has yet been held.

The legislature has never made specific appropriation for institutes. What has been done has been with such funds as the board of agriculture was willing to appropriate from its income, derived from the tax on commercial fertilizers. The lecturers have received no compensation for their services. This work has been entirely a labor of love, the lecturers from the college and experiment station contributing their vacation time to the institute work, thus giving up their own time needed for rest and recuperation in order to make the institutes as efficient as possible. Altho institutes have been held each year since the work first began, it was not until 1903 that any serious effort was made toward forming permanent local organizations. In that year an advance agent was sent out to secure at each point the names of the leading farmers of the section, and then to these personal invitations were sent urging them to come to the meeting. In this way a much larger attendance was secured last summer than in any previous year, and at each institute thus held a local organization was effected consisting of a secretary and a chairman and an institute committee composed of a member from each township of the county. It is the purpose to hereafter hold an institute each year in every county where a local organization has been formed to work it up beforehand.

While institutes have been held in North Carolina every year for the past fifteen years, little has been done as compared with States having a large annual appropriation enabling them to employ outside aid. It is believed, however, that as much has been accomplished in North Carolina with the amount of money spent as any other State has been able to effect with a similar sum.

Institutes specially designed to aid the negro farmers of the State have been organized. Four of these were held last summer, were well attended, and at all of them the closest attention was given. Some negro farmers are present at all of the institutes, and they are always welcome.

It is the purpose in future to divide the institute lecture force into two sections in order to cover a larger number of counties than has been possible with a single corps of men. In this way many more institutes can be held, and it is believed that increased interest in the work can be thus secured.

What the institute needs in North Carolina is thoro organization, a liberal appropriation from the legislature for meeting its expenses, and a director who can devote his entire time to the work. In no other way can the institutes be made as effective as they should be. The commissioner of agriculture and the director of the station have duties that fully occupy their time and require their attendance at their offices. The supervision of institutes interferes with their regular work. Thoro organization, some money, and a director who has this work and no other in hand will make the institutes a powerful educational force in agriculture. They have already accomplished much good, and have led the farmers to depend more and more on the help that the experiment station and the department of agriculture can give them, and have greatly increased the correspondence of the station with the farmers of the State who are now seeking the aid of the station more than is done in most other States.

The amount expended for institute work in this State in 1904 was $850. The traveling and hotel expenses of the lecturers is all that the board provides. Other States, with large appropriations from their legislatures, have been able to call in and pay for the best help from outside of State lines. North Carolina, on the other hand, has depended solely on her own citizens for her institute teaching force, men willing to contribute their time and strength, often at great personal inconvenience and not infrequently involving actual loss.

There were 33 institutes held in 1904, with an attendance of over 6,000 persons. The farmers of the State are taking greater interest in the work each year, and the day is not far distant when the legislature will be willing to recognize the institutes, not only by a law organizing them but by appropriating money sufficient to make them what they should be.

NORTH DAKOTA.

So far as any authentic record can be found the first farmers' institute in North Dakota was held at Casselton on March 25 and 26, 1894. This was followed by one at the agricultural college, Fargo, on June 21, both of these institutes being under the auspices of the Society of United Farmers of Cass County. It is quite probable that during the time in which the Grange was active in North Dakota that meetings approaching the nature of farmers' institutes were held by the lodges of this society at different points in the State. At such meetings, however, the program was presented by farmers who had made more or less of a success in their respective localities. The Casselton meeting would, it seems to the writer, be properly the first farmers' institute held in North Dakota. Two men prominently identified with this institute were J. B. Power, acting as president of the agricultural college, and J. C. Gill, a prominent farmer living near Casselton. This institute was addrest by members of the faculty of the agricultural college, in addition to leading farmers of the county, and undoubtedly was a great success, altho the society under whose auspices it was held failed to hold any further meetings. In fact, the society itself soon ceased to exist.

In addition to the two institutes named in the opening paragraph, two other meetings were held the same year, one at Mayville, Traill County, on June 27, and the other in connection with the assembly of the Chautauqua Association, at Devils Lake, on July 5 and 6. The expenses of holding these institutes were met in each instance by contributions from the business men, solicited by local committees, who arranged the program, advertised, and conducted the meetings. Members of the agricultural college faculty took an active part in all these institutes, as well as those held thruout the State for a number of years.

Recognizing the great advantage of some systematic farmers' institute work, the president of the agricultural college, thru the board of trustees, urged that a small annual appropriation be provided sufficient to pay the traveling expenses of institute speakers. No appropriation, however, was made for this work, altho in the annual reports of the experiment station and the biennial reports of the college farmers' institutes were discust in each succeeding report by the director of the station and the president of the college.

While no appropriation was provided for a number of years for this work, different members of the faculty took active part in such institutes as were held. In nearly all instances a local committee, believing in the practical results obtained from the institute, would arrange to defray the necessary expenses of the speakers outside of the papers and addresses that could be furnished by the near-by farmers, and thus the interest in the institute was not allowed to lapse entirely.

At the sixth biennial session of the legislative assembly there was introduced and past an act to regulate the manufacture and sale of dairy products, section 17 of which act made the assistant dairy commissioner director of farmers' institutes and gave him charge of all matters relating thereto. It was further provided that the expenses of such institutes should be limited to the actual expenses of travel and entertainment of the speakers and lecturers. The writer, having been appointed and accepted the position of assistant dairy commissioner, planned to devote a certain amount of the funds appropriated for the expenses of the office to the holding of farmers' institutes. As it was impossible to use any of the funds appropriated for securing speakers the agricultural college had to be depended upon largely for such speakers. From July 1, 1899, to June 30, 1900, 25 farmers' institutes were held at an expense of $524.39. All the members of the station staff who assisted in the work were willing to give their services, but the number of institutes held had to be limited to the time they could spare from their duties at the college and station.

The year following institutes were conducted along the same plan, the total number of meetings held being 18. In all instances the place where the institute was held furnished a hall properly heated and lighted, supplied most of the advertising matter, and, in some instances, entertained the speakers.

At the seventh biennial session of the legislative assembly a law was past creating a farmers' institute board and appropriating $1,500 per year for institute work. For the first time in North Dakota it was now possible to secure an institute corps who could devote their whole time to the work The large number of applications which had to be refused showed how popular the institute was becoming thruout the State. The first year a total of 25 meetings were held, followed the next year by 19.

A large number of numerously signed petitions were presented at the next legislative assembly, and the members thereof responding to the demands of the farmers increased the appropriation to $4,000 per annum. The first year under the new appropriation will close June 30, 1904, by which time there will have been held 46 institutes, in which one of the best institute corps in the entire country took part. At the same time it was necessary to refuse 25 applications for meetings where all the requirements of the institute board were complied with, and in some cases the local committee even offered to pay all the expenses of the institute.

It is believed that an excellent idea was hit upon for creating a governing board for the farmers' institutes. This board is composed of the president of the board of trustees of the agricultural college, the commissioner of agriculture and labor, director of the experiment station, the professor of agriculture, and the professor of dairying of the agricultural college. Here is a board that is vitally interested in the agriculture of the State, that is thoroly in touch with the methods of education along agricultural lines, and one that in nearly all cases will contain a majority of members who have had experience in institute work, so that a permanent and experienced management is practically guaranteed to the farmers' institutes. Just as soon as the appropriation is made sufficient to warrant, a superintendent of institutes will be engaged, who will have entire charge of the institute corps, of the correspondence relating to institutes, and the publication of the Institute Annual. At the present time the work of correspondence, advertising, and the publication of the Institute Annual is in the hands of the writer, who is secretary of the institute board. An institute conductor is secured for the season, who has entire charge of the corps while in the field.

Fully believing that the institute work was not completed or well rounded out without a complete report of each year, there has been prepared an Institute Annual, the first number of which was issued in 1900. The publication of this annual has been continued, an edition of 10,000 copies being sent out each year. That this work is well received is evidenced by the large demand for back numbers. The report for 1904, being the fifth of the series, is now under preparation and will be ready for distribution by the opening of the next institute season.

Since the first institutes were held there has been considerable change in the subjects presented and demanded by the farmers of the State. North Dakota being a wheat-growing State, the most interesting subjects at first were those pertaining to wheat growing, and fully 75 per cent of the questions asked at the institutes were along the line of this crop. The subjects have gradually changed, until now dairy husbandry, the live-stock industry, corn growing, poultry raising, horticulture, etc., receive fully as much attention from the institute corps, as well as the farmers, as that of wheat growing.

As an experiment last year (1904) a lady speaker was attached to the institute corps for a part of the season, and it was found to be an important addition to the institute work.

But ten years have elapsed since the holding of the first institute in the State, and for only five years of that time has the State provided any funds for systematic work. That the work is appreciated and demanded by the farmers is shown in the increased appropriations and the increased number of applications for institutes.

OHIO.

In the development of farmers' institutes in Ohio there were three distinct stages, namely, the period of suggestion, the period of experiment, and the period of successful operation.

The first suggestion relative to lectures for the benefit of farmers seems to have come from Dr. N. S. Townshend, who later became dean of the college of agriculture, Ohio State University. Under date of February 15, 1845, he wrote as follows:

> Had we a State agricultural society, with a good board of managers, or should the legislature constitute a State board of agriculture, then either of these might select a

sufficient number of competent individuals to lecture, after the manner of medical institutions, on all the sciences having relations with agriculture. To one lecturer might be assigned geology and mineralogy, with their relations to draining, well digging, etc.; to another, chemistry, with its innumerable applications; to another, botany and vegetable physiology as applied to gardening, orcharding, and field culture; to another lecturer zoology, comparative anatomy, and physiology, showing their bearing upon the management of domestic animals; to another, the principles of pathology and therapeutics and their relation to the treatment of the diseases of animals, and all the operations of a surgical nature which the farmer is required to perform; then to another, natural philosophy and the application of its principles in the perfecting of farming implements, etc.

Doctor Townshend, under date of September 14, 1845, made the following suggestions to the young farmers of Ohio in relation to the formation of farmers' clubs:

> Of the utility of such associations there can be but one opinion. With a good one in every township the agriculture of our State might be speedily regenerated; without them little, comparatively, will be accomplished. And now the most convenient season for holding evening meetings is approaching and must not be allowed to pass away unimproved.
>
> Meetings ought to be held at least monthly and as much more frequently as they can be made sufficiently interesting. They may be occupied with—
>
> First, lectures. These should embrace all the sciences having any application to agriculture.
>
> Second, reports. The visiting committee should visit the farm of every member at least once during the year and present a full report on each farm.
>
> Third, discussion. Let some subject be announced for conversation and members one after another give their opinion or experience in relation to the matter. (Ohio Cultivator, 1845, pp. 149–150.)

The organization of farmers' clubs in every township was the best suggestion that could have been made under existing conditions. There were only 84 miles of railroad in operation in the State in 1845, and the difficulty in transportation alone would have made the institute of to-day impracticable.

In the Ohio Cultivator of October 15, 1846, M. B. Bateham (later a member of the Ohio State Board of Agriculture) said:

> In regard to lectures, we hope that the State board of agriculture will take some action upon the subject, and that several competent persons may be engaged to lecture in different parts of the State where desired during the coming winter. We know of no way by which more good could be accomplished at the present time.

The Ohio State Board of Agriculture, created by an act of the general assembly, past February 28, 1846, at its second meeting, held October 28 of the same year, adopted a resolution recommending the formation of township and neighborhood farmers' clubs or societies for the purpose of mutual improvement by means of libraries of agricultural books and periodicals and discussions and lectures upon agriculture, and asking gentlemen possessing the requisite knowledge of science and agriculture in different parts of the State to assist in the great work of promoting agricultural improvement by delivering lectures to farmers as they may be desired or have opportunity, especially during the season of fall and winter, and in places where clubs or societies may be formed for such purposes. (Ohio Agricultural Report, 1846, pp. 17–18.)

At a meeting of the Lorain County Agricultural Society, January 28, 1847, the following resolutions were adopted:

> *Resolved*, That we procure lecturers to lecture in each town in the county on agriculture, and solicit persons to become members of the Lorain County Agricultural Society.
>
> *Resolved*, That if any person will procure a house and notify the inhabitants of his town the time of meeting, and inform the lecturer, he will be present at the time and give a lecture on agriculture, etc. (Ohio Cultivator, 1847, p. 36.)

At a meeting of the Ohio State Board of Agriculture, held December 4, 1850, Ex-Governor Allen Trimble, president of the Ohio State Board of Agriculture, introduced a resolution to appoint Professor Mather State agricultural chemist and corresponding secretary of the board, and suggested that were it deemed necessary and could be accomplished by the professor "lectures on the subject of agriculture should be delivered." (Ohio Agricultural Report, 1850, p. 53.)

The second period was that of experiment in institute work. A course of agricultural lectures was inaugurated at Oberlin, December 4, 1854, to continue for three months. There were four departments in charge of the following gentlemen:

Dr. James Dascomb, Chemistry in its application to soils, manures, animal and vegetable life, domestic arts, etc.

Dr. N. S. Townshend, Comparative Anatomy and Physiology, with special reference to the feeding and breeding of stock; History and Description of Domestic Animals; Veterinary Medicine and Surgery, Entomology, etc.

Dr. John S. Newberry, Geology and Mineralogy, Botany, etc.

Prof. James H. Fairchild, Natural Philosophy; Agricultural Mechanics; Farm Implements; Meteorology; Elements of Engineering and Land Surveying; Rural Architecture; Lanscape Gardening and Farm Bookkeeping. (Ohio Cultivator, 1854, p. 286.)

Only a few young men took advantage of these lectures at Oberlin, so during the winters of 1855 and 1856 they were held in Cleveland, but evidently with no better success, as they were then discontinued. Doctor Dascomb, at the close of the last term, remarked to a friend, "Ohio is not ready for this work and will not be for twenty years."

There seems to have been no further special effort in this direction for a number of years, but good seed had been sown. Farmers' clubs and other farmers' organizations increased rapidly in number and much valuable information was disseminated thru these organizations and thru the medium of the agricultural press.

During all these years Doctor Townshend was teaching the doctrine of higher education for the farmer with unflagging zeal in addresses to county agricultural societies, farmers' clubs, etc.

A few years after the opening of the Agricultural and Mechanical College the board of trustees decided (under the inspiration of Doctor Townshend), in order to make "the college more immediately serviceable to the agricultural interests of the State, to provide a course of free lectures on topics of practical interest to farmers." In 1878 an effort was made to establish in the college a course of lectures on the sciences relating to agriculture. It was proposed to have four lectures a day for ten weeks. Only seven farmers responded, so the effort was abandoned for that year.

The following year the matter was taken up by the granges of the State, and when the lecture course opened, January 9, 1879, there was a large number of intelligent and earnest farmers in attendance, over one hundred names being entered on the class register. The course continued four weeks and all the members of the faculty took part, Doctor Townshend delivering two lectures a day and the others one each.

The second term began January 13, 1880, but the time was reduced to three weeks. The attendance was about the same as the previous year.

A third course was held in January, 1881, continuing ten days.

September 14, 1880, Dr. W. I. Chamberlain, secretary of the Ohio State Board of Agriculture, asked for definite authority "to cooperate with county or other local agricultural societies and granges in calling and organizing farmers' institutes or agricultural conventions during the present fall and winter." (Ohio Agricultural Report, 1880, p. 19.)

A resolution was at once adopted appropriating $1,000 from the earnings of the State fair for the purpose of inaugurating farmers' institutes in Ohio, and during the winter of 1880–81 the good work began by holding 27 institutes.

The following season, 1881–82, the same number was held, 27; in 1882–83, 33; 1883–84, 39; 1884–85, 41; 1885–86, 43; 1886–87, 47; 1887–88, 81; in 1888–89 the board was able to appropriate only about one-half the amount that had been expended the previous year for this work, and there was consequently a decrease in the number, only 53 being held; in 1889–90, 62 were held.

The farmers' institute had proved to be a valuable educational factor to the agriculturists of the State, and the general assembly, recognizing this fact, on April 26, 1890, past "An act to provide for the organization and support of farmers' institute societies." This law provided from the general fund of each county a per capita allowance of 5 mills, but not to exceed $200 in any county; two-fifths of this amount to go to the State board of agriculture for the payment of per diem and expenses of speakers appointed by the board, and three-fifths to go to the local societies for their expenses.

This substantial recognition of the importance of the work gave fresh impetus to it. In 1890–91 there were 124 institutes held under the auspices of the board; in 1891–92, 141; in 1892–93, 151; in 1893–94, 150; in 1894–95, 151; in 1895–96, 157; and 87 counties took part in the work. But the board had now reached that point where it was impossible, with the means at its command, to increase the number of institutes, altho the demand was constantly growing. Again the general assembly came to its aid, and on April 27, 1896, amended the "act providing for the organization and support of farmers' institute societies," making the per capita allowance 6 mills instead of 5 mills and dividing it equally between the State board or agriculture and the local societies, limiting the amount available in any county to $250.

During the winter of 1896–97 the board held 212 farmers' institutes, and for the first time in the history of the State all the counties—88—took part in the work. In 1897–98, 234; in 1898–99, 250; in 1899–1900, 256; in 1900–1901, 260; in 1901–2, 252; in 1902–3, 242; and in 1903–4, 247.

In addition to the regular farmers' institutes held under the auspices of the Ohio State Board of Agriculture a large number of independent institutes have been held each year, some of which have reported, but many have failed to do so; hence it is impossible to give an accurate report of the number . In 1890–91 there were no reports made; in 1891–92, 8 reported; in 1892–93, 14; in 1893–94, 14; in 1894–95, 27; in 1895–96, 31; in 1896–97, 25; in 1897–98, 29; in 1898–99, 20; in 1899–1900, 20; in 1900–1901, 20; in 1901–2, 26, in 1902–3, 24; and in 1903–4, 30. All farmers' institutes are held two days, with two speakers in attendance, employed by the board.

The State farmers' institute held its first session in Columbus, Tuesday, January 11, 1887, and it has held annual two-day sessions in Columbus since that time during the weeks of the annual meetings of the State board of agriculture. These institutes have always been well attended by the farmers, horticulturists, and stock breeders of the State. During the continuance of these no county institutes are held, thus giving all interested an opportunity of attending, and they prove most successful, both in point of numbers and interest. Nearly all the institute lecturers in the employ of the board attend these State meetings and add materially to their interest and value.

Since the inauguration of regular farmers' institutes in 1880–81 the State board of agriculture has received the hearty cooperation and valuable assistance of the professors of the agricultural college of the Ohio State University and the officers of the Ohio Agricultural Experiment Station, and the help thus given has been a great aid in making the work a success. The board has also received the assistance of prominent educators thruout the State and from sister States; of men who are authorities in their special lines of work—agriculture, horticulture, stock breeding, etc.—of intelligent, earnest, practical farmers; and all these gentlemen deserve a share of the credit of success.

OKLAHOMA.

The settlement of Oklahoma, in 1889, occurred just about the time the farmers' institute movement began to gather headway in the States. The establishment of the agricultural college and experiment station followed within two years after the settlement, but it was not until 1893 that interest in the institute form of extension work was aroused.

The first farmers' institute organization in Oklahoma of which there is any record was effected at El Reno, the county seat of Canadian County, in October, 1893. A similar organization was effected at Pond Creek, the county seat of Grant County, early the following year and less than six months after the settlement of that part of the country. Some interest was also manifested in other localities and it was fostered and stimulated with varying degrees of success by the faculty of the agricultural and mechanical college and the staff of the experiment station. At best, however, the interest was desultory and efforts at organization were sporadic and there was nothing like continuity or permanency in the results achieved. The experiment station authorities labored faithfully to arouse an interest among the farmers of Oklahoma, yet, in the very nature of things, they could not act as organizers in distant localities, and without proper organization there could be nothing done in the way of systematic institute work.

Early in 1901 there was prepared and introduced into the Territorial legislative assembly a bill providing for the organization of a Territorial board of agriculture. With some modifications, the measure was finally past, but the law remained inoperative for nearly two years because of lack of appropriation. The board thus created consisted of six members, two elected each year for a three-year term, by a meeting composed of one delegate from each county farmers' institute. These county farmers' institutes are permanently organized and chartered under the provisions of the board of agriculture law.

Thru these organizations as a medium the board of agriculture has been laboring with satisfactory results in an endeavor to develop a farmers' institute system. In this it has had the cordial cooperation and active support of the experiment station authorities. During the year ending June 30, 1904, which was the first year of the operations of the board of agriculture, 52 institute meetings were reported to the board, with an aggregate attendance of 5,400. With the county institute organizations as a basis, it is proposed to extend and expand the system until it reaches into every agricultural community in Oklahoma. In 1904 the board of agriculture contributed $300 for institute support. The local organization met the other expenses from private contributions.

OREGON.

The first farmers' institute in this State was held at the State capitol, Salem, December, 1888. This institute was very well attended, and the discussions were good. It was held under the auspices of the agricultural college, and the institute practically marked the beginning of a new era of farming in western Oregon. Up to this time the growing of cereals and the production of wool occupied the attention of our farmers. There was no thought of soil impoverishment and scarcely any attention given to dairying or other forms of animal husbandry. In fact, at this time domestic live stock, except the work horses and fattening swine, had to maintain an existence in the open field thruout the year.

These institutes at their earliest incipiency attracted the attention of our most progressive citizens. Among the college faculty who contributed to their success were President B. L. Arnold, Director E. Grimm, E. R. Lake, the college botanist, horticulturist and entomologist, and P. H. Irish, chemist. This staff of workers was ably assisted by Mr. Fitz Roy Osborne, of the Michigan Agricultural College. Some of the most prominent laymen who were early workers in this educational branch of the college were R. P. Boise; Thomas H. Tongue, afterwards elected to Congress; J. T. Apperson, subsequently president of the board of regents of the Oregon Agricultural College; J. Voorhees, later master of the State Grange; Richard Scott, and the present director of the Oregon Experiment Station.

Several institutes were held during the winter of 1888, among the most successful of which were those at Salem, Hillsboro, and Tangent.

From the beginning farmers' institutes in this State have been popular. It is incomprehensible, however, why an effort has not been made to invoke State aid for the extension of the work, a work which has been recognized on every hand to be of exceptional value to the agricultural interests of the State.

The institutes conducted in this State have largely been of the intensely practical type, altho they have been favored with the presentation of many scientific facts from very able men. A helpful feature of the institute has been stereoptically-illustrated lectures on breeds and types of live stock, fungus, and insect pests of fruit, garden and field crops. These illustrated lectures have been practically the equivalent of natural object lessons.

Farmers' institutes have been twofold in their beneficial effect upon the agricultural conditions of the State. In addition to their immediate benefit to the active farmer, they have been a potent factor in bringing the farmers in close touch with experiment station workers, hence have been exceedingly helpful to the experiment station in bringing to its attention the principal evils besetting the agriculturists.

About twenty farmers' institutes have been held in this State each year for the past fourteen years. All of these institutes have been conducted under the auspices of the agricultural college. Their influence upon the agricultural practises of the State has been very marked. Improved and up-to-date methods of agriculture in all of its various ramifications are evident on every hand and are directly traceable to the far-reaching effect of the institute. The press of the State has also been a valuable supplement in promulgating agricultural information. It has generously donated its space in publishing the discussions at these institutes, thus bringing the work directly within the reach of nearly every farmer in the State.

While the comparatively few institutes which have been held thruout the State within the past sixteen years have been of great value to agriculture, there is at present urgent need for a wider extension of this work. Agriculture is constantly changing in its various aspects. Large farms are being subdivided into smaller farms, which means a more intensified system of farming. Thus a great many new problems are constantly arising to confront the farmer. Then, again, a large influx of farmers is steadily pouring into the State who, in the main, have been accustomed to different conditions of farming. Hence they are desirous of securing practical information on many subjects, just the information that is usually obtained at institutes.

PENNSYLVANIA.

If the early history of the farmers' societies organized in Pennsylvania for the advancement of agriculture could be written, it would be a proper introduction to the discussion of the origin of farmers' institutes in that State. As early as 1785 there was organized in Philadelphia an agricultural society known as the "Philadelphia Society for the Promotion of Agriculture." This was, perhaps, the oldest organization of the kind in this country.

The first farmers' institute held in Pennsylvania by State authority was on May 22, 1877, when the board of agriculture, which had been created by act of assembly of May 8, 1876, called a meeting of its members at Harrisburg for the consideration of the agricultural interests of the State. This board was composed of representatives elected by the several county agricultural societies, one representative from each of the 67 counties, together with 3 persons appointed by the governor and 6 members ex-officio, who were connected with the several departments of the State administration. These 76 representatives had sole charge of the organization and management of farmers' institutes for about eighteen years, until the creation of the department of agriculture, when the institutes were transferred to this department. Until 1885 the board of agriculture had no specific appropriation from the State from which to bear the expenses of the institutes. The service of its members was altogether gratuitous. The expenses were met by the several localities in which the institutes were held, altho a small amount was used from the appropriation made to the board for its ordinary expenses in order to meet the traveling expenses of the lecturers.

Among the influences at work during this period in the direction of institute development was the interest taken in the movement by the Pennsylvania State College. In 1882 this institution held a farmers' institute at the college, continuing from January 17 to 27. The course consisted of 40 lectures given by the college professors, aided by specialists who were secured from outside to present certain important agricultural specialties. No charge was made for the instruction given or for the use of the public rooms of the college. These annual institutes were held for three years. At the end of this period they were discontinued, owing to the fact that the attendance was found to be largely local, and the maintenance of the course disarranged the work of the institution to an extent that was not, in the judgment of its officers, justified by the results.

From that time until the present, however, the State college and the experiment station have continued to contribute lecturers each year from the college faculty and the station force for institute work. For several years from three to five members of the institution were continuously in the field during the institute season. For a portion of this time the college and station bore all of the expenses of their members employed in the institute work, but after appropriations began to be received by the State board of agriculture for institute purposes that board paid the hotel and traveling expenses of the lecturers, their salaries as instructors in the college and station being continued by the institution while engaged in institute work.

By act of assembly of 1885 the legislature granted an appropriation of $1,000 to the State board of agriculture for the actual and necessary expenses of holding farmers' institutes. This appropriation, tho small, was of great assistance to institute work. It enabled the board to pay the expenses of all of the lecturers and in some instances to add a slight compensation for service. In 1887 the legislature increased the annual appropriation to $3,000. As a consequence, the number of institutes was correspondingly increased, until in 1890 sixty-five were reported as having been held during that year.

In 1891 the appropriation for institute purposes was still further increased to $7,000 per year, and during that year the number of institutes held was 84. Sixty-two of the sixty-seven counties of the State now had representatives on the board of agriculture.

The institute work continued under the direction of the State board of agriculture, as has been stated, until the creation of the department of agriculture, under an act approved March 13, 1895. The institutes of the winter of 1894–95 were therefore the last that were conducted under the old system. One hundred and forty-eight were held during that year.

Under the old system the control and direction were entirely in the hands of the local members of the board of agriculture, and the appropriation by the State was distributed by the secretary among the counties in accordance with a pro rata distribution arranged by a committee of the board. The apportionment for the year 1894–95 gave to each county $65 and then 2 cents per farm additional. The local manager selected the dates for his institutes and secured such aid as in his judgment the circumstances required, and paid this help out of the funds in his hands which had been contributed by the State. It resulted in some counties having as many as six institutes while others with proportionately the same funds held but one. There was also an interference in the dates for holding meetings, this matter being largely left to the local managers. There could consequently be little uniformity of action, and considerable difficulty was often experienced in securing desirable speakers for meetings owing to this conflict in time. There was also the criticisms made by other agricultural organizations in the counties that in many cases they had no voice in the arrangement and direction of these institutes. Their members accordingly held aloof because they felt that they were to a degree ignored.

The new law undertook to correct these defects, and made it the duty of the director to fix the dates for all institutes that were to be arranged for in such a way as to save expense in traveling and economize time. The following extract from the law of 1895 organizing the new department of agriculture, shows the method adopted for the control of the institute work:

SECTION 4. There shall be one deputy secretary who shall be appointed by the governor for the term of four years, at a salary of $3,000 a year, who shall also be director of farmers' institutes.

SEC. 5. That it shall be the duty of the superintendent of institutes to arrange them in such manner as to time and place of holding the same as to secure the greatest economy and efficiency of service, and to this end he shall, in each county where such institutes are to be held, confer and advise with the local member of the State board of agriculture, together with representatives duly appointed by each county agritural, horticultural, and other like organization, with reference to the appointment of speakers and other local arrangements.

On October 1, 1895, Prof. John Hamilton, of State College, Center County, Pa., was appointed by Gov. Daniel H. Hastings as first director of farmers' institutes under the new law, and served in that capacity until 1899. During his tenure of office the institute system was reorganized, and institutes were held annually in every county in the State. Interest in the work increased each year, and the appropriation for institute purposes was raised in 1897 from $7,500 to $12,500 per annum, and in 1901 to $15,000 per annum. This appropriation was made to the department of agriculture, and its expenditure was entirely under the control of the secretary. An entirely new method of distribution was agreed upon, by which a certain sum was granted to the local directors in the several counties, and a portion withheld for the purpose of paying institute lecturers employed by the State department. It was made on the basis of granting two days of institute to every county having not over 1,000 farms; three days to each county having more than 1,000 farms and not over 1,500; afterwards one day for each 1,500 farms or fraction thereof. The sum of $12.50 per day was granted to the local director to be used in meeting the local expenses. The State furnished two additional lecturers, who were paid by the department.

In 1899 Professor Hamilton was appointed by Gov. William A. Stone, secretary of agriculture, and was succeeded by Mr. A. L. Martin, of Enon Valley, as deputy secretary and director of institutes, who has continued in that position until the present time. The appropriation for carrying on the work for the past two years has been $17,500 per year, and from the month of December until March the director has had five corps of lecturers traveling continually thruout the State giving instruction in institutes along all phases of agricultural work. At these meetings instruction is given respecting the most approved methods of dairy management, including the feeding and stabling of cows, the care of milk, and the manufacture of butter and cheese, and how and where to market these products most profitably. In soil improvement instruction is given as to the best methods for securing a supply of nitrogen, phosphoric acid, and potash. Information is also imparted in the management of swine, sheep husbandry, market gardening, horticulture, beekeeping, etc.

An important feature of the institute work in this State is that which prescribes that in every institute meeting an entire session shall be given to the discussion of some particular topic that is of general interest, and that has been prescribed by the State department for all the institutes of the Commonwealth. One session of the institute is devoted to the subject of education—of a kind best adapted to the development of rural life.

The effect has been to secure the enactment of a law providing for the centralization of the common schools and for the transportation of the children to and from these schools. The purpose has been to secure for country children such instruction as will be more in keeping with their surroundings, and be better calculated to fit them for their life work than has heretofore been given.

A woman's session is also held in every institute thruout the State. The topics discust are the country home, its sanitation, its domestic arrangement, and the social environments of country life.

The farmers' institutes of Pennsylvania have long since past the problematic stage and are to-day filling an important place in the agricultural and commercial interests of the Commonwealth. Their system of management, altho not in every respect complete, has been fairly satisfactory and has been patterned after by several other States. The continued and increasing demand for agricultural instruction is daily coming in from every portion of the State, showing that the farmers are alive to the importance of adopting accurate and improved methods in the conduct of their farm operations, and that they realize that their hope of future advancement lies in the application of the new facts that science is daily discovering and adapting them to their use. To the work of developing and distributing these fundamental truths the farmers' institutes of Pennsylvania are consecrated.

PORTO RICO.

Farmers' institutes have not been organized in Porto Rico.

RHODE ISLAND.

The farmers' institutes in Rhode Island are conducted under authority granted by the general assembly in an act past May 19, 1892, section 4 of which is as follows:

> The board [of agriculture] shall hold one agricultural institute in each county annually, either independently or in connection with any society or association or other organization devoted to the same general objects, and may hold as many more as it shall deem expedient, and shall, as far as practicable, encourage State and local societies in the interests of agriculture.

In the annual report of the State board of agriculture for the year 1890 Governor Ladd is quoted as saying that "Four meetings were held in different parts of the State before the 1st of January, 1890. These were small and tentative, for the purpose of ascertaining whether such meetings could be made popular and profitable." Encouraged by the success attending them, the first formal institute for 1890 was called at Kingston court-house January 23, 1890, and was addrest by several eminent speakers, among others Mr. A. W. Harris, assistant director of the Office of Experiment Stations of the United States Department of Agriculture; Dr. H. F. Wheeler, of the State experiment station at Kingston; Dr. Austin Bowen and President Andrews, of Brown University.

The second institute was held in Providence February 26 and 27, 1890, and was formally opened by Governor Ladd, and an address of welcome by the mayor of Providence. The meeting was held at Manning Hall, Brown University. The attendance was large and enthusiastic. Speakers of national reputation were present. Prof. W. O. Atwater gave an admirable résumé on the condition of agriculture in the United States, and Edward Burnett, of Massachusetts, delivered an excellent lecture on dairy cattle, dealing particularly with the feeding of ensilage, which had at this time assumed considerable importance in the United States. Institutes have continued to the present time, showing that they have met a need in the agriculture of the State that is general and much appreciated.

The arranging for the holding of institutes is committed by the State board of agriculture to its secretary, and the expenses are paid by the board out of an annual appropriation of $15,000, appropriated for the purpose of carrying out the several provisions of the act by which the board of agriculture is constituted. Twelve institutes were held during the year 1904, composed of 21 sessions, with a total attendance of 1,260. The amount appropriated for institute purposes was $600, and the entire cost was $620. Twelve speakers were upon the State lecture force, all of whom were members of the faculty of the State agricultural college or of the experiment station force.

The dates, places, and programs are arranged by the director. Two thousand five hundred copies of reports of the proceedings were printed and distributed.

SOUTH CAROLINA.

In 1887 the legislature of South Carolina made it obligatory upon the board of agriculture to hold farmers' institutes. A few were held under the provisions of that act. Several years later Clemson Agricultural College was established, and the duties of the board of agriculture, so far as it related to the holding of farmers' institutes, were devolved upon the board of trustees of Clemson Agricultural College.

A law of South Carolina, enacted in 1893,[a] provides that—

> The board of trustees of Clemson Agricultural College shall have power to hold agricultural conventions composed of delegates from each county of the State; * * * and to conduct farmers' institutes at such times and places as may appear expedient, and they are authorized to use such parts of funds under their control as may be necessary to meet the expenses of conducting such institutes.

From this time until the present farmers' institutes have been held in most of the counties every year, with increasing popularity, closing each season with a several days' institute held at Clemson Agricultural College. Last year 33 institutes were held, having a total attendance of 8,690. Fifteen lecturers were upon the State institute force; 9 were contributed by the agricultural college and 6 by the experiment station. The expenses amounted to $600. A round-up institute at the close of the season, extending over 12 sessions, was held at the college, having a total attendance of about 1,500 persons.

A committee of the board of trustees of Clemson Agricultural College makes out the programs for the ensuing year and appoints an officer to take charge of the work of conducting the meetings. The rule adopted by the board is to require that an invitation shall be received from not less than 15 farmers in a locality before an institute will be granted, and it is also required that those desiring institutes must have their petition in the hands of the president of the board of trustees on or before June 10. This petition must designate a suitable place for holding the institutes, and the locality will be expected to provide either a suitable building or seats in some grove for the comfortable accommodation of those who attend the institute.

The director appoints the dates on which the institutes will be held, giving due notice to the petitioners in each locality. Thereupon they are expected to advertise the meeting thruout the territory which the institute is to reach. The appropriation is made by the trustees of the agricultural college from the college and staff funds.

SOUTH DAKOTA.

The first farmers' institutes in South Dakota were held in the winter of 1889–90, and were conducted under the direction of James H. Shepard, chemist in the South Dakota Agricultural College. The college at that time had no winter term, and an institute was planned to be held at the institution, to continue for several weeks. The next winter, 1890–91, the same method was tried, but in both cases with indifferent success. It was found that the number of farmers th[illegible]uld be induced to attend the institute meetings was not sufficient to justify the expense. This plan was therefore abandoned, and meetings were arranged to be held in various parts of the State, to continue for about three days. This proved much more acceptable.

The work was conducted by the professors of the college. No funds were available for meeting the expense, and the localities in which the meetings were held were required to furnish a hall free of charge and also to provide for the advertising of the institutes and the entertainment of the speakers.

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[a] Revised Statutes, 1893, sec. 1132, par. 10.

In 1895 Professor Shepard was formally placed in charge of the institute work as director. No appropriation was made by the State to meet the expenses of the work. Meetings, however, were held during the seasons of 1895 and 1896, and some good work was accomplished.

In 1897 the legislature took up the institute question, and the State engineer was made director of farmers' institutes, and the sum of $1,000 per year was granted for meeting the expenses of the work. With this the director, S. A. Cochran, employed a lecturer on dairy science and one on domestic economy for about two months each winter. N. E. Hansen, professor of horticulture of the agricultural college, was added to the force, but with no compensation other than his salary received from the college. With this corps of instructors a considerable number of two-day institutes were held in various parts of the State, aided by such local talent as the several communities were able to furnish. Two institutes were held each week, and a system was rapidly being inaugurated which promised excellent results.

The legislature of 1900–1901 failed, however, to make any appropriation for the institutes, and since that time up until the beginning of 1905 no institutes were held, except a few local meetings conducted by the farmers themselves.

The legislature of 1904–5, at the request of the officers of the State agricultural college, appropriated $5,000 per year for farmers' institute purposes, and has placed the oversight of the work in the hands of the president of the college and the regents of that institution. The way, therefore, is open for resuming the work, and it is the intention of the college authorities to inaugurate a vigorous campaign along institute lines during the coming winter.

TENNESSEE.

The oldest agricultural organization in the State is known as the East Tennessee Farmers' Convention, which held its first meeting in 1875, and has held annual meetings ever since at Knoxville. Its membership embraces all of the East Tennessee counties. The present officers are: W. Getys, Athens; A. M. Soule, secretary, Knoxville.

The institute movement under the auspices of the State department of agriculture was first inaugurated during the administration of Commissioner Allison in 1893. No appropriation, however, was made for its maintenance at that time. Four institutes were held in that year at the following places: Knoxville, Pulaski, McMinnville, and Jackson. Commissioner Allison continued this work during his administration of four years, as did also Commissioner Essary during 1897–98.

Thomas H. Paine was appointed commissioner of agriculture in 1898, and recognizing the importance of this work, secured an appropriation of $2,500 per year for institute work for a period of four years.

The commissioner of agriculture selects the lecturers, arranges the programs, and decides the times and places for holding institute meetings. The State is naturally divided into three distinct geographical sections—eastern, middle, and western Tennessee. Originally the institute organizations were formed into several divisions. It was during Mr. Paine's administration that county organizations instead of division organizations were attempted with success. Interest continued to grow in the work, until under the present administration an appropriation of $5,000 per year has been secured for the use of the farmers' institutes. During the past year 69 county institutes were held, and 3 division institutes in the different grand divisions of the State. The average attendance of the county institutes was 140 and the division institutes 1,200.

TEXAS.

Fourteen years ago, in 1892, under the management of a prominent agricultural journal printed at Dallas, a series of farmers' institutes was held in Texas with the cooperation of the railroads, the agricultural and mechanical college, and a number of volunteer lecturers, including such men as R. F. Butler, Doctor Folsetter, W. S. Marshall, and others. Those institutes were followed by a request addrest to the Texas legislature for State aid in the support of the movement. The legislature did not then appreciate the importance of this work, and when asked for an appropriation for its support refused to provide any funds for that purpose.

In July, 1897, the Farmers' Congress, a State organization, adopted a new constitution, in which the following resolution was incorporated:

> *Resolved*, That the objects of this organization shall be to develop accurate and scientific knowledge of the arts of agriculture, to establish and encourage farmers' institutes, etc.

This statement of purpose respecting the institutes produced no definite results until 1902, when the journal before referred to supplied a State organizer at its own expense, and, with the assistance of public-spirited men, aided by the railroads, a series of institutes was held, beginning with one at Terrell, August 27, and continuing thruout the autumn and winter. The effect of this series of meetings upon the general public was such that the legislature of Texas in 1903 appropriated $5,400 to the Agricultural and Mechanical College of Texas for farmers' institute purposes for two years.

Immediately upon the passage of this act a member of the faculty of the college was appointed by the board of directors to take charge of organizing and conducting institutes. R. L. Bennett was chosen institute director and was later succeeded by J. W. Carson, of College Station.

During the past year the director has organized 150 institutes in the several counties and has also formed a large number of truck-growers' associations. The director and the president of the college arrange the dates, places, and programs for institute meetings. All of the local expenses are met by the citizens of the community in which the institute is held, including very frequently the entertainment of the State lecturers. One hundred and forty-four institutes were held during the year, 140 of these being one-day institutes and 4 two-day. The total number of sessions was 178 and the attendance 15,130. There were 34 lecturers on the State force, 23 of whom were supplied by the agricultural college and experiment station, who contributed two hundred and eighty-four days of time. The cost of the institutes for the year was $3,950. Two thousand and seven hundred dollars of this was from the State appropriation and the balance from an appropriation made by the United States Department of Agriculture out of the boll weevil fund, to be expended under the supervision of the president of the college as collaborator.

County organizations are formed under a constitution and by-laws suggested by the State director. By the terms of this constitution the local societies agree to meet once each month for the discussion of agricultural questions. Two round-up institutes were held, at which 1,250 persons were in attendance. The railroads have cooperated generously by supplying transportation to the lecturers, and in many instances furnishing complete entertainment while the lecturers were on their road.

UTAH.

Up to July 1, 1896, the only farmers' institute work done in the State was represented by occasional popular talks given by members of the faculty of the Agricultural College of Utah, and of the staff of the experiment station. On July 1, 1896, a bill approved by the governor March 28, 1896, went into effect, granting the agricultural college the sum of $1,500 annually for the purpose of conducting farmers' institutes in the State and for publishing an annual report of institute work.[a]

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[a] See U. S. Dept. Agr., Office of Experiment Stations Bul. 135 (Revised), p. 31.

Under this act institutes have been held each year and seven farmers' institute annual reports have been prepared and published. During the first two years after the passage of this act it was attempted to interest the farmers by sending out parties of four to six members of the college and station staff, who traveled by rail and by team over the larger portion of the State, holding farmers' institutes in the towns and villages on the way.

After 1898 the work was conducted mainly by sending out speakers to localities that made requests for assistance. This was found to be a very expensive method of doing the work, and after the year 1900 farmers' institute tours were arranged. Two or more speakers from the college would spend one or two weeks doing institute work, holding a meeting every day in different places. This method was also found rather unsatisfactory, partly because of the great expense and partly also because the college in most cases had to plan the trips, advertise the meetings, and frequently the people felt that the officers of the State institute were forcing their meetings upon the farmers.

About two years ago the plan was adopted of holding, as far as possible, only county institutes and of sending speakers from the college to such institutes only when formal requests for such help was made by the proper county organizations. This plan is working very well, is satisfactory in every respect, and, besides, is economical. Two to four speakers are sent out to take part in the institutes in two or more counties. The times of holding the farmers' institutes are so arranged that one county institute follows another, in order to allow the speakers to make the very best use of their time. The county institutes extend over at least two days, each day consisting of three sessions for the men and three for the women. The counties do all the work of advertising and other preparation.

The following circular announcement has been issued by the college, showing the method to be pursued in securing an institute:

> In compliance with the law, the faculty of the college has been authorized to hold farmers' institutes in the various counties of this State, and, as far as possible, to make the subjects discust at each institute meet the special needs of the locality where it is held.
>
> All expenses of the meeting will be met by the college, and authority will be given for the printing of notices and programs to those making application for institutes. For the present it is recommended that institutes be held during one day and evening, devoting the day session to papers and discussions upon special farm topics, and the evening to lectures and addresses on subjects of more general interest to the community at large. Local speakers and writers are expected to assist in the exercises of the institute by discussing subjects in which they are most interested or in which they have had successful experience. If an institute is desired in any community, those interested are requested to select the topics that are believed to be of the most interest to the locality, determine upon a date for the meeting, and arrange for such local speakers as may be desired. Usually not more than two professors from the college can attend an institute at one time.

The interest in the farmers' institute work is rapidly growing in this State. Numerous local institutes and societies have been organized. Many county institutes are also in existence, and it is now, as it always has been, quite impossible for the college to meet all the requests made upon it by the above-mentioned appropriations. At least one-third of the appropriation is spent annually in publishing the Annual. The remaining $1,000 does not allow much traveling in a State as large as is Utah.

VERMONT.

By an act of the general assembly of the State of Vermont approved November 22, 1870, the governor of the State, the president of the State agricultural college, and six persons to be appointed by the governor and confirmed by the senate were constituted the "Vermont Board of Agriculture, Manufactures and Mining," to hold office until the 1st day of November, 1872, their successors to be appointed biennially.

The first meeting of the board was subject to the call of the governor, at which meeting the organization of the board was perfected, and consisted of His Excellency John

W. Stewart; James B. Angell, president State Agricultural College; Peter Collier, secretary of the board, and the following persons as appointed by the governor and confirmed by the senate: A. B. Halbert, of Essex; Charles H. Heath, of Plainfield; Frederick Holbrook, of Brattleboro; Pitt W. Hyde, of Castleton; Z. E. Jameson, of Irasburg, and N. B. Sanford, of Whiteriver Junction.

The act of the general assembly which provided for this board also conditioned that the board shall hold at least one business meeting each year and as many more as they deemed expedient, to which the people of the State shall be invited to participate for the investigation and discussion of matters relating to agriculture, horticulture, manufactures, and mining, and a sum not exceeding $2,500 was appropriated.

During the two years this board was in office nine public meetings were held in different towns of the State, at which the subjects of fruit culture, grass culture, practical agriculture, fertilization, education, manufacturing, and mining were presented by experts on the different subjects and thoroly discust by people present at the meetings.

From the first the board had the hearty cooperation of the best farmers of the State, also those interested in the different branches covered by the act creating the board.

In 1873–74 nineteen public meetings were held by the board, at all of which the attendance was large and great enthusiasm shown by the general public. Papers on subjects pertaining to agriculture were read and discust, including dairying, fruit culture, sheep, cattle, and horse breeding, farm buildings, stock feeding, sugar making, etc.

In 1875–1882 meetings were held thruout the State, usually with good attendance, and much interest taken in them by the public.

In 1883–84 forty-seven meetings were held and the number of addresses given at these meetings and under the direction of the board was 731.

In 1885–86 sixty-four meetings were held and the number of addresses given was 922.

In 1894 the amount to be expended by the board was raised and limited to $5,000, and the board was given jurisdiction over the importation or introduction of horses and other domestic animals into the State such as had been exposed to, or believed to be infected with, any contagious disease. They were given power to examine the animals in the State supposed to be infected and under certain conditions to kill or quarantine the same.

The report of 1894–95 shows twenty-seven public meetings, the subjects presented and discust covering all branches of farming and stock raising.

In 1897 twenty-seven meetings were held thruout the State, from one to three days each, having an attendance of from 150 to 600 people. In 1898 twenty-seven meetings were held, in 1899–1900 sixty-three, and in 1901 forty-three.

In 1902 the general assembly past an act constituting the governor, the president of the University of Vermont and State Agricultural College, and three persons appointed by the governor and confirmed by the senate, and "who shall hold office for two years," to constitute a board of agriculture, conditioned that the board shall hold at least one meeting in each county annually, and may employ such talent as lecturers as they deem expedient.

In 1903 forty-nine meetings were held, and the interest shown by the general public was very gratifying to the board and the several persons who appeared as instructors.

At the biennial session of the legislature of 1904 the governor appointed as the three additional persons to serve for the ensuing two years George Aitken, of Woodstock; Earnest Hitchcock, of Pittsford; and Dana H. Morse, of Randolph, as the members of the board. These appointments were confirmed by the senate. At a meeting of the board George Aitken was elected as the secretary, so that the board as now constituted consists of His Excellency C. J. Bell, president; M. H. Buckham, of the University of Vermont; George Aitken as secretary, and Earnest Hitchcock and Dana H. Morse.

During the thirty-four years of its existence the board of agriculture of Vermont has each year held its meetings and kept up its interest in the development of the agriculture of the State. It has extended the scope of its work from year to year until now its lecturers cover a large field in their instruction, and their work is proving of great benefit to the farming interests of the State. The board has been judicious in the employment of men as lecturers, selecting only those who are experts in the several lines of farming, as stock raising, fruit culture, dairying, sugar making, sanitary farm buildings, etc.

The work of the board has stimulated the farmers of the State to aim at a much higher grade of farming. Its lecturers have taught them the value of commercial fertilizers and their more economical use, the importance of the exercise of care, and the use of scientific methods in the feeding of animals, the value of keeping accurate records of milk production, the conservation of moisture in the soil, and the use of various forage crops both as food for animals and as furnishing fertility for the betterment of their farms. In these and numerous other respects the influence and teachings of the board and of the specialists employed as instructors in the institutes have been of untold value to the farming interests of the State.

In 1904, 48 institutes were held, with an estimated attendance of 10,000 persons. The secretary of the board of agriculture is the superintendent of institutes and has, under the direction of the board, control of the work of fixing the dates and places for the institutes and of arranging the programs.

VIRGINIA.

Farmers' institutes seem to have taken definite form in Virginia about the year 1890. In the reports of Thomas Whitehead, commissioner of agriculture for 1888–89, reference is made to the advisability of holding institutes, and quotations are made from the reports of the directors of institute work in some other States. The first meeting was held at Chatsworth Farms, owned by R. B. Chaffin, near the city of Richmond, September 25 and 26, 1890. The meeting was well attended and addresses were delivered by a number of prominent farmers and scientists. A summary of the proceedings, together with the papers read, is contained in the report of the State board of agriculture for the year 1890. The expenses of the meeting seem to have aggregated $169.03. It is interesting to note that even at this early date the services of scientific experts were considered of importance, for Professors Massey and Alvord addrest the meeting. Doctor McBryde, president of the Virginia Polytechnic Institute, delivered a number of notable addresses on agricultural education and experimental work at meetings held in later years. Since the inception of the farmers' institute movement, the officers of the Virginia Experiment Station have been frequently called on to deliver addresses before meetings held in all parts of the State, a service cheerfully rendered on their part.

The initial meeting was so successful that the State board was encouraged the next year to appropriate the sum of $250 for farmers' institutes to be held in each Congressional district of the State upon a written petition signed by 300 farmers in the district. Under this plan four institutes were held in the year 1891, namely, at Chatsworth, Charlottesville, Bedford, and Pulaski, and the expense incurred for speakers was $890.11. Many of the papers read at these meetings are published as an appendix to the commissioner's report for 1891. On the whole, farmers' institutes seem to have gained ground and to have found favor in the different sections of the State during the year.

The institute work was continued in the year 1892, meetings being held at Alexandria, Cape Charles, Grange Camp, Burkeville, and Lynchburg, and $1,425.50 was expended in the work. The meetings seemed to have been highly successful, judging from the commissioner's report, and he calls attention to the value of the meetings and suggests the advisability of the State making a special appropriation for the maintenance of institutes. As heretofore, a number of the best papers read before the institutes were published as a part of the commissioner's report for the year 1892.

The movement seems to have waned somewhat during the year 1893. Only three meetings were held, namely, at Lynchburg, Harrisonburg, and Manassas. The total cost was $532.35. Many of the papers read are reproduced in the commissioner's report.

Only two applications seem to have been received for institutes in 1894, while only one was held at Tappahannock, and the expense was $75.

The institute movement seems to have revived a little according to the report of the commissioner for 1895. Four meetings were reported for that year from the first, sixth, seventh, and eighth districts, the total expense being something like $400. The meetings were fairly well attended, but as the matter had been left entirely in the hands of the farmers and no systematic effort made for the organization of the meetings, it is not surprizing that a large part of the special appropriation made by the board for holding institutes should have been returned to them.

To Thomas Whitehead, commissioner of agriculture during the period under discussion, belongs the honor of first endeavoring to organize and place farmers' institutes on a permanent basis in the State of Virginia. His efforts for the time and under the conditions which confronted him were certainly successful. While these gatherings were not as far-reaching in their influence as those of the present day, the information given out was of immense value to those attending and has paved the way for the more systematic efforts which the board of agriculture in cooperation with the Virginia Experiment Station has now inaugurated.

The commissioner's reports for the years 1896, 1897, and 1898 are not available, and therefore it is not possible to say just what progress the institute movement made during that peroid. A few meetings were held by the officers of the experiment station at various points in the State at the request of a number of leading farmers, and more would have been held but for the fact that no specific appropriation was available for the work; and so, while the station and college authorities fully recognized the value of institutes, they were unable to take a very active part in them because of a lack of funds, but the institutes have always had their cordial support, and every effort has been made to further them. Thomas Whitehead was succeeded by G. W. Koiner as commissioner of agriculture.

In Commissioner Koiner's report for the year 1899 reference is made to the value of farmers' institute meetings and attention is called to the excellent work being done in Wisconsin, Iowa, and various other States where large appropriations were made for that specific purpose. It would appear from this statement that the farmers' institute movement had practically died out in Virginia. No report is available as to where or when meetings were held or what the attendance was. The item of expense reads as follows: Appropriations for bulletins, institutes, and reports, $878.08. It is not likely, therefore, that many meetings were held within the year.

In the report for 1900 the commissioner states that seventeen counties were visited and that the meetings were fairly successful. No reference is made to the places where the meetings were held. The disbursements of the board show that $3,000 was spent for these meetings.

Further reference is made to the institutes in the report for 1902, but no account is given of places where the meetings were held or of the number of counties visited. One thousand two hundred and forty dollars was spent for institute work according to the financial statement of the board.

In the year 1903 the commissioner's report states that "institute meetings have been well received." The number is not given. One thousand one hundred and forty-nine dollars was expended that year for institute purposes. In 1904 reference is made to the increased demand for farmers' institutes. The statement of expenditures shows that $1,610.10 was used for conducting them.

Until 1903 the holding of farmers' institutes was practically under the direction of the commissioner of agriculture, but with the adoption of the new constitution in that year an appropriation of $500 from the general revenues of the State board of agriculture was made to each member of the board for holding institutes in his Congressional district.[a]

At a joint meeting of the State board of agriculture and the board of control of the Virginia Polytechnic Institute, held about a year ago, a plan of cooperation between the two boards was decided on, whereby the members of the experiment station staff were made available as lecturers at farmers' institutes in the State. Since that time a number of members of the board have seen fit to avail themselves of the services of the various members of the experiment station staff, and about thirty institutes have been held in the last six months in five Congressional districts of the State at the following places: Roanoke, Wytheville, Danville, Stuart, Rocky Mount, Martinsville, Tazewell, Pearisburg, Abingdon, Gate City, Pulaski, Harrisonburg, New Market, Strasburg, Winchester, Berryville, Luray, Eastville, Onley, Hallwood, Mathews, Gloucester, Orange, Culpeper, Crewe, The Plains, Fairfax, and Leesburg. The experiment station officers have assisted in organizing and conducting these meetings and are making every effort in their power to promote the development of the farmers' institute movement in the State, tho unpaid for this service. The meetings have been well attended, the average not falling far short of two hundred. Considering that this is one of the first efforts made in the State to hold institutes in a systematic manner, the results are particularly gratifying. The farmers attending have evidenced the greatest interest in the meetings, both by their presence and the variety and number of questions asked the speakers. In every county visited there has been a request for a meeting next year, and if the good work so well commenced is followed up by the individual members of the board a new era in farmers' institutes in Virginia is in sight.

The value of farmers' institutes is so clearly recognized and their merits have been so fully set forth before the public that it is not necessary to further emphasize this point. The discussion of important subjects in these meetings will certainly be productive of much good. All that seems to be needed in Virginia in order to make the farmers' institute movement a permanent and successful means of improving and ameliorating agricultural conditions, disseminating useful and practical information, and adding materially to the development of the State, is a definite and aggressive policy with regard to the organization of the meetings in the several Congressional districts. The fact that the farmers are ready and anxious to avail themselves of the information to be obtained thru these meetings has been very clearly demonstrated in every county where the meetings have been properly advertised.

WASHINGTON.

In an act approved March 28, 1890, creating a commission of technical instruction to establish a college of agriculture and mechanic arts in accordance with the provisions of the land-grant act of 1862 of the General Government, the general scheme of instruction and methods for carrying out the processes of the new institution were specifically set forth. In section 3 of this act a required part of the work of the college is definitely stated to be "to hold farmers' institutes at such times and places and under such regulations as it may determine." This was reaffirmed in 1897 in an act defining the duties of the State Agricultural College and School of Science.

Immediately upon the opening of the agricultural and mechanical college the first of a series of farmers' institutes was held under the auspices of the college at Colton on January 30, 1892, C. W. Richardson presiding, with E. E. Alton as secretary. There were 62 persons in attendance. The college was represented by President Lilly and Professors Scobey, Lake, and Munn. The subjects discust were the purposes and aims of the Washington Agricultural College, dairy farming, the tree crop for eastern Washington.

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[a] There are ten Congressional districts in the State.

The second institute of the series convened at Garfield, Whitman County, Saturday, February 20, 1892. President Lilly called the meeting to order, whereupon Senator A .C. McCroskey was elected chairman and A. S. Beach, secretary.

The chairman, in announcing the object of the meeting, stated that the agricultural college faculty were present to discuss with others various subjects of interest to farmers and also to extend the objects and workings of the college. The farmers were present to aid in the consideration of the subjects to be discust. The number in attendance is given at 137.

The third institute was held at Pomeroy, Garfield County, Saturday, May 15, 1902. President Lilly, calling the meeting to order, stated the object to be that of discussing the various subjects of interest to the farmer and fruit grower, and also to explain the objects and workings of the college, and bring the college faculty in close touch and sympathy with the industrial interests and people of the entire State. At this meeting there were 109 persons in attendance.

The legislature at its session of 1902 past an act making appropriation for farmers' institutes in which the number to be held each year is definitely stated. The clause is as follows:

> For maintenance and conducting farmers' institutes under direction of the regents of the Washington Agricultural College and School of Science, $2,500 per year: *Provided*, That at least one institute shall be held in each county of the State in each year.

Under the existing organization the president of the college is the superintendent of farmers' institutes and the dean of agriculture is the field agent and has direct control of the execution of the work. The State is districted into four circuits—northwest, southwest, northeast, and central—with an organizer in charge of each circuit. County organizations have been established thruout the State, which are intrusted with the duty of making local arrangements for institute meetings. In 1894, 57 institutes were held; 12 were one-day, 44 were two-day, and 1 was a three-day institute. The total number of sessions was 259, and the attendance is given at 15,922. Twelve speakers are upon the State institute force; 8 of these are from the faculty of the agricultural college and the staff of the experiment station.

WEST VIRGINIA.

The first movement for the organization of a system of State and county farmers' institutes in West Virginia was made by A. D. Hopkins, of Kanawha Station, Wood County, who issued a call on February 10, 1889, for a meeting of farmers to be held at the residence of Omar Page, Lockharts Run (now Roosevelt), Wood County, on February 16, 1889.

This meeting was held at the time and place designated, with a number of farmers present and with Omar Page in the chair, and A. D. Hopkins, secretary. The object of the meeting was explained by the secretary as follows:

> The object of this meeting is to take steps toward organizing a State farmers' institute society for the purpose of organizing and conducting a system of farmers' institutes, farmers' clubs, and farmers' meetings in Wood County, and to assist in extending the system thruout the State.

The plan proposed to organize a society to be known as the "Farmers' Institute Society of West Virginia," the membership to be composed of farmers and others in Wood and other counties of the State who were interested in agricultural pursuits. The society was to have for its main object the organization of a system of farmers' institutes in the counties represented by the members, and to assist in extending the system to other counties of the State with a view to establishing the work upon a universal and cooperative plan as follows:

Members of the State society were to organize county institute societies; members of the county societies were to organize farmers' clubs and special meetings. The membership fees and annual dues for farmers' clubs, 5 cents; for county institutes, 20 cents, and for State institute societies, 50 to 75 cents; the money thus collected to be used by each club or society for the necessary expenses of conducting their respective meetings and institutes. The farmers' clubs were to be open to members and invited guests; the county institutes to be open and free to all who desired to attend.

The secretaries of the clubs, societies, and meetings were to keep a record of programs and important and interesting facts presented at such meetings and report the same in writing to the secretary of the State society, who would also act as general superintendent of the system and furnish an annual report for publication.

The State society was to hold one or two institutes each year, to which county societies and farmers' clubs would be expected to send delegates and speakers, assist in obtaining special lecturers, and in securing an audience.

For the financial support of the proposed system membership fees, annual dues, and individual contributions were to be depended upon until State aid was secured.

After a discussion of the plan it was decided to call a meeting of the farmers of Wood and adjoining counties for the purpose of discussing the matter further and to take some active steps toward the proposed organization. March 13 was selected as the day of meeting, and the place the court-house in Parkersburg. A circular letter dated March 2, 1889, was prepared and sent out, and notices were also given by the county papers calling attention to the meeting, and referring to the necessity of farmers' institutes being conducted in West Virigina as they were now being held in Ohio and other States.

The meeting was held at the time and place mentioned and was attended by some of the most progressive and intelligent farmers of that section of the State. S. S. Stone, of Selden, Wood County, was chosen temporary chairman, and A. D. Hopkins secretary.

The director of the experiment station, John A. Myers, was present, and in his address explained the objects of the experiment stations and how the experiments and investigations would benefit the farmers. In closing he referred to the farmers' institute as one of the best educational institutions for farmers that was ever started, and that he would like to see them organized in every county in the State.

The plan of organization for farmers' institutes that had been presented by Mr. Hopkins at the February meeting was taken up and discust, after which the secretary moved that steps be taken toward effecting a permanent organization. This was carried, and 15 names were presented for charter membership. On motion of A. A. Keller, the organization was made permanent, and the temporary officers were retained.

The secretary then presented a draft of a constitution for an institute society, which was referred to A. A. Keller and James McMechen, the president and secretary, a committee to report a constitution to a succeeding meeting.

This committee met at the Commercial Hotel in Parkersburg on March 16 and 23 and decided upon a constitution, which was reported to a general meeting of the society at Parkersburg on June 1, 1889, and adopted. The Farmers' Institute Society of West Virginia was then permanently organized, with S. S. Stone president, J. T. McMechen vice-president, A. D. Hopkins secretary, and Omar Page treasurer.

The constitution, as adopted, provided for the election of a president, vice-president, secretary, and treasurer. The secretary was made superintendent of institutes, and was empowered and directed to form neighborhood farmers' clubs. A membership fee of 25 cents was fixt as the annual dues of each person.

Under this organization a "Strawberry" meeting was held at the store of J. W. Dudley on June 8, 1889. The fruit committee held another meeting at the fair grounds in Parkersburg on July 27, and a picnic and farmers' institute was held on August 15, at which T. B. Terry, of Ohio, was engaged to lecture. This was the first regular institute held by the society and was very successful. About 300 persons were in attendance.

At a meeting of the society held in December arrangements were made for the holding of an institute at the court-house in Parkersburg on January 21 and 22, 1890.

This meeting proved a success beyond all expectation. John A. Myers of the experiment station; D. D. Johnson, of Tyler County; Oliver Garals, of Pleasants County; D. G. White, of Pennsylvania; A. A. Kellar, Judge Loomis, Mayor J. B. Gibbens, J. A. Hutchinton, H. C. Henderson, and A. D. Hopkins, of Wood County, were the principal speakers.

An evening session was held for the purpose of discussing plans for interesting farmers thruout the State in institute work and to take steps toward securing State and other aid in carrying out the objects of the Farmers' Institute Society of West Virginia.

At the close of the institute S. S. Stone, D. D. Johnson, and John A. Hutchinson were appointed a committee to go before the legislature, then in session, and urge upon that body the importance of appropriating an amount of money sufficient to enable this society, the board of regents of the State University, or both, to organize and conduct farmers' institutes in the State. Three bills were prepared by A. D. Hopkins and submitted to this committee on February 3, 1890, one of which was selected and presented on February 16 by the committee before the joint committee of finance of the senate and house, asking for an appropriation of $5,000 for farmers' institute work. The bill past the house, giving the Farmers' Institute Society of West Virginia $2,000 for the purpose of holding farmers' institutes, the vote standing 36 to 15. The bill then went to the senate, where an amendment was made to strike out the Farmers' Institute Society and insert the board of regents of the West Virginia University, which was carried. An amendment was then proposed to place the funds under the control of the executive committee of the board of regents for the experiment station, which also carried. At this point unexpected opposition was encountered. Senator Knott, of Jefferson County, the master of the State Grange, moved to strike out the entire clause making the appropriation, and as this was offered by the farmers' representative in the senate, it carried and the bill was defeated.

At a meeting of the society April 29, 1890, in Parkersburg, the secretary, in an address upon the subject of farmers' institutes, discussing the failure of the State appropriation, stated:

> It appears now that the only available resource from which we can look for aid is thru the board of regents of the State University. I would therefore move that someone be appointed to attend the annual meeting of the board at Morgantown next June to solicit such aid in this work as is in their power to give, until we can determine whether or not State aid will be extended at the next session of the legislature.

After a discussion the secretary was appointed to go before the board of regents of the State University at its annual meeting in June and solicit aid from that body in establishing institute work in the State. On June 11 the secretary, in pursuance of this action, presented the resolutions of the society before the board of regents and requested them, in the name of the institute society, to assist it in holding a State institute at Parkersburg in August, and to otherwise assist the society in extending a system of farmers' institutes to other counties of the State. The board of regents, in compliance with this request, appointed D. D. Johnson, of the agricultural experiment station, to assist in organizing county farmers' institutes in the different counties of the State, his expenses being paid out of the station fund. Colonel Johnson proceeded to organize county institutes during the following month (July, 1890) in Lewis, Harrison, and Barbour counties.

In the meantime the institute society took active steps toward holding a State institute at Parkersburg on August 28 and 29, 1890. The institute was held at the time and place mentioned, but was only a partial success.

During December, 1890, Colonel Johnson conducted farmers' institutes in Marshall, Wetzel, Tyler, and Pleasants counties.

On January 21, 1891, the director of the experiment station and the secretary of the Farmers' Institute Society arranged for a series of farmers' institutes which were conducted by members of the experiment station staff, assisted by county institute societies and individual farmers in Wood, Barbour, Mineral, Berkeley, Monroe, Kanawha, Cabell, Mason, and Jackson counties. Two days were devoted to each institute, including one or two night sessions. Other institutes were held during the year.

The legislature of 1891 had provided for the formation of a State board of agriculture, which took up the work and conducted a series of institutes thruout the State in Greenbrier, Wood, Harrison, Berkeley, and Jefferson counties, and assistance was rendered in conducting these institutes by members of the experiment station staff.

The second semiannual meeting of the State Board of Agriculture of West Virginia was held at Morgantown October 5, 1891. There were present T. C. Atkeson, president, B. F. Fisher, C. R. Sperrow, J. M. Rowan, and H. M. Turner, secretary. To this session the director and members of the State experiment station and the members of the board of regents of the State University were invited to meet the board for the purpose of exchanging views upon matters pertaining to the work for which the State board of agriculture had been established. D. D. Johnson, agriculturist of the experiment station, addrest the board relative to its future work in cooperation with the experiment station. He spoke of the difficulty in getting the farmers of the State to study the science of progress in farming, and the tendency to find fault with any effort made to interest them in institutes and other work that would be likely to assist them, and he also spoke of the advisability of the board and the director of the experiment station cooperating in the institute work. A committee, consisting of members of the board of regents of the State University, met with the board at a special session. This committee was composed of the following gentlemen: J. A. Robinson, C. L. Smith, A. E. Bennett, and J. F. Brown. There were also present at the meeting J. A. Myers, director of the experiment station, and A. D. Hopkins, entomologist. Doctor Myers addrest the meeting at some length upon the work the station was doing, and was followed by Major Bennett, Mr. Brown, and others of the committee of regents. T. C. Atkeson, president of the board of agriculture, addrest the meeting and stated that the board desired to act in harmony with the university and station.

Mr. Brown, of the committee of the board of regents, offered the following resolution:

Resolved, That it is the sense of this committee that the agriculturist do, upon such reasonable occasions as may be approved by the director of the station, attend and lecture upon appropriate subjects at the institutes held thru the State under the auspices of the State board of agriculture, and that permission be granted the professor of agriculture in like manner to attend and lecture at such institutes, with the approval of the executive committee, and this resolution shall apply as well to the director of the station and to the other members of the station staff, the latter at the direction of the said director; and it is further

Resolved, That the actual traveling expenses of such agriculturist and professor in and about said business shall be paid out of such funds of the station and department as may be available therefor.

The resolution was adopted and the meeting adjourned.

The board of agriculture met the next day, October 7, 1891, in the library of the experiment station, and upon invitation J. A. Myers, director, and the station staff, appeared and a joint meeting was held. The resolution past by the committee of university regents was read and thoroly discust. A plan was finally agreed upon for holding farmers' institutes in each Congressional district in the State and accordingly there were held, under the auspices of the board, institutes at the following places: Ronceverte, November 5 and 6; Parkersburg, November 9 and 10; Clarksburg, November 17 and 18, and Charlestown, November 19 and 20. The experiment station staff held institutes at Kingwood and other places in the State about the same time.

The farmers were slow to realize the value of the institutes, and the work did not progress very rapidly for some time, except in Ohio County, where a society had been organized by the local farmers and an active interest taken in the institutes. The first institute held in Ohio County met at Wheeling, March 26 and 27, 1891, and a permanent society was organized with the following officers: J. M. Brown, president; J. W. Garvin, vice-president; J. G. Leasure, secretary, and L. P. Sisson, treasurer. This organization was maintained by its members until 1896, when it received assistance from the State board of agriculture. From March, 1891, to January 30, 1904, from one to two successful institutes were held each year.

In 1892 a farmers' agricultural society was organized at Pleasant Valley, Marshall County, which held regular meetings for the discussion of farm topics. This organization formed the nucleus of what may be considered one of the best institute organizations in the State. The meetings are well attended by the farmers and their families, and one session of each institute is devoted to domestic science. A similar organization has been maintained in Barbour County for several years, where the farmers of their own accord hold regular meetings for the purpose of "educating the mind and training the hand." It is easy to understand why such a county is called one of the banner institute counties of the State. The society meets regularly each month, in addition to holding one or two annual institutes.

These counties are referred to in this connection because of the progressive spirit they manifested in the early history of the institute movement in the State. Great progress is being made in many of the other counties, where from one to four institutes are held each year.

From March, 1891, until October, 1897, the institutes were mostly conducted by the members of the board, each member being assigned to look after the institutes in his district. No compensation was allowed for the time and services rendered. Actual traveling expenses incurred were paid out of the appropriation made to meet the current expenses of the board. Gradually the farmers began to appreciate the work that was being done to improve their condition, which created a greater demand for institutes.

It was soon found that some special effort must be made to meet the demands of the farmers for additional meetings and also to extend the institutes into the more remote sections of the State.

With this in view, a resolution was past at a meeting of the board held October 4, 1897, creating the office of institute director, and C. C. Brown, of Charleston, was elected to the office for the term of two years. In prescribing the duties of the director the resolution says, in part:

> The duties of said director shall be to superintend and have direction of and arrange for the holding of all farmers' institutes in the State, under such rules and regulations as may be prescribed by the board, and as set forth in chapter 22, section 5, of the act of 1895.

Under the supervision of the institute director, a special effort was made to hold at least one institute in each county, and the work was prosecuted with more or less success. In some parts of the State they were missionary in character, since they opened the way for the performance of a more substantial work in the future. The success attending the efforts of the institute director fulfilled the hopes that inspired his appointment to the extent that the office was continued.

At the meeting of the board, October 18, 1899, D. M. Sullivan was elected institute director for the term of two years. The name of the office was changed at the meeting of the board held April 7, 1902, to that of superintendent of institutes, and J. B. Garvin was elected for the remainder of that term. At a meeting held October 5, 1903, he was reelected for the term of two years.

Various plans have been devised to create interest among the farmers and to insure good attendance at the meetings, so that the board might be justified in sending out first-class instructors. A recent plan adopted by the board is to require that petitions be sent in requesting institutes. Each society is furnished with two blank petitions for the purpose of securing the names of farmers who agree to help work up the institute. One copy of the petition, signed by at least ten or more farmers, is returned to the office of the superintendent of institutes, where it is placed on file. One copy is kept by the secretary of the local society. Ample time is given for circulating and returning these petitions before the institute committee meets.

The institute committee is appointed by the board, and consists of two members of the board and the superintendent of institutes. The committee examines and considers each petition and arranges the places and dates into divisions. The committee also selects the institute instructors who are to have charge of the different divisions. When this work is completed, a list of topics is furnished the local committee of each society, from which topics for the program are selected and returned to the office of the superintendent of institutes. who has them printed and returned, together with printed posters to be used for advertising the meetings. It is urged that due notice of the meetings be published in the local papers. Circular letters are also mailed to individual farmers in the community where the institute is to be held, signed by the instructor who is to have charge, and printed postal cards are furnished the secretaries, to be used in a similar manner.

This plan systematically carried out has been more successful than any other which has yet been tried. From 80 to 90 institutes are held each year in the 55 counties of the State.

WISCONSIN.

In Wisconsin the State Agricultural Society, the Northern Wisconsin Agricultural Society, the Dairymen's Association, and the Horticultural Society all were holding meetings of an institute nature, and Doctor Henry, of the agricultural college, had held farmers' meetings at different points in the State long before the State system of farmers' institutes was thought of, and it is more than probable that the effects of these agricultural meetings, or institutes, and the good they were doing, had much to do in bringing about the establishment of an organized State system.

The law establishing a system of farmers' institutes for Wisconsin was introduced into the Wisconsin legislature of 1884–85 by C. E. Estabrook, of Milwaukee.

The bill introduced by Mr. Estabrook past the Wisconsin legislature in 1885. The act carried with it an annual appropriation of $5,000. Two years later it was amended and the appropriation was increased to $12,000 per annum.[a]

The amended act gave authority to the board of regents of the State University to hold farmers' institutes and empowered the board to make such rules for their regulation as it might deem proper.

The farm committee of the university board of regents selected the late W. H. Morrison as the first superintendent, with an office room in the capitol building, and gave him almost absolute power in organizing and perfecting the institute system. Since 1894 the present superintendent has conducted the work.

Mr. Morrison had experience as a farmer, county superintendent of schools, and secretary of the well-known Walworth County Agricultural Society, whose annual fairs have become celebrated thruout the State and country. His good judgment and remarkable organizing ability rapidly brought the Wisconsin system of institutes into such good working order that other States and Provinces, formulating systems for themselves, drew upon Mr. Morrison very largely for their plans. An average of 44 meetings were held during the first two years with the $5,000 appropriation. During the next seven years an average of 70 meetings were held, and in the past ten years an average of 112 have been held annually, with 11 cooking schools additional, each season during the past eight years. For the past ten years the aggregate attendance has been about 50,000 per year.

The Wisconsin institutes are what the name indicates—genuine farmers' institutes, being actually held by the farmers themselves. The superintendents of the work both have been practical farmers, and the workers are chosen from the best farmers in the State, those whose live stock and farm products have won prizes at the greatest shows in the country and have topt the best markets for farm products; men who had a reputation, not only in their own localities but thruout the State, as its best stock breeders and farmers before they were called to the institute platform. The farmers ask for these meetings and feel that they are their own.

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[a] See U. S. Dept. Agr., Office of Experiment Stations Bul. 135 (Revised), p. 34.

During 1886–87 Superintendent Morrison became convinced that the best thoughts and suggestions brought out in the different discussions should be preserved, and accordingly began the publication of the Wisconsin Farmers' Institute Bulletin. This has been continued annually. The material for this bulletin is secured by holding a round-up institute, at which the institute workers of the State are brought together along with some of the professors from the agricultural college and a number of institute lecturers from other States. The papers, addresses, and discussions presented at this meeting are stenographically reported and edited into a bulletin.

In 1887, 31,000 copies of Bulletin No. 1 were issued. In 1890 the issue was increased to 40,000, in 1895 to 50,000, and in 1896 to 60,000. One hundred thousand could now be profitably used, but the funds will not permit the publication of so large an issue. Eight thousand cloth-bound bulletins are turned over to the superintendent of public instruction to be placed in the school district libraries of the State. The balance of them are distributed at the institutes and thru the local press, creameries, cheese factories, farmers' clubs, agricultural societies, farmers, and business men.

The cost of the preparation, editing, printing, and distributing of this bulletin of 320 pages is about $6,000. Part of this, however, is returned from funds received for the limited amount of advertising placed in its pages.

Midwinter fairs under the local management are held in connection with many of the two-day winter institutes where prizes for products of the farm and home, varying in amount of premiums from $10 up to $2,500, have been offered. Where properly managed this fair feature adds very much to the interest.

The methods followed in conducting Wisconsin institutes partake both of the features of a school and of a conference. A petition, signed by farmers and business men, is sent in to the management, in which they proffer a free hall and agree to look after the local details without any expense to the State fund. The institutes are located by the superintendent by selecting from the places making application in such a manner as to best cover the entire State. These meetings are thoroly advertised by sending out posters and programs and by notices thru the local press.

The winter meetings are two days each. Upon the first day three sessions are held and but two upon the second day. The evening session, which is held the evening of the first day, is devoted to educational topics, in which the school officers usually take part with the institute workers.

In attending each meeting the conductor of the corps of workers impresses upon the farmers the fact that it is their meeting and that they are expected to take an active part in all the discussions.

The speakers give an opening lecture of from fifteen to twenty minutes in length which is followed by a twenty to thirty minute discussion, the greater part of which is devoted to asking questions by the farmers, and to brief, pointed answers to the same by the institute workers, with an occasional short statement of experience and experiments by those present.

The conductor at each meeting promptly shuts off all partizan political discussions or statements based on ignorance, prejudice, or superstition. Charts are used extensively in all discussions. Models and animals are also sometimes used.

A stock-judging institute was held a few years ago under the direction of the superintendent of farmers' institutes at the Waukesha County Fair, since which time several counties have adopted the plan and require the judges to briefly state the reasons for their awards.

All meetings are reported to the superintendent by the conductors in charge. The reports of each meeting aim to give a general view of the agricultural conditions of the section in which the meeting is held and are made upon uniform blanks furnished to each conductor for the purpose. One object of these reports is to aid the superintendent in planning future work in the same district.

Since 1895 from 10 to 16 one-day institutes have been held in the timber districts of central and northern Wisconsin, where farmers are making homes by clearing up the timber land that has been logged over. These meetings have been very successful and in great demand, and we believe have done much toward developing better methods of farming, better bred live stock, and the dairy industry in particular. Many cheese and butter factories have been established as the results of these meetings.

The farmers of Wisconsin at first were suspicious of the farmers' institutes, looking upon them as a political move or an advertising medium for stock breeders or for the agricultural college and the State university, and quite often spoke of the institute workers and speakers as theorists. This spirit has been entirely overcome by the employment of practical farmers as institute instructors, until now the farmers of Wisconsin have full confidence in the institute and its teachings.

The Wisconsin system, while it may not be the best under all conditions and circumstances, seems to be very satisfactory to Wisconsin farmers. It lays claim to being the oldest organized State system in the country and has been, to some extent, studied by representatives from other States and from foreign countries, and some of its plans have been worked into many systems now in operation thruout the country.

The work in Wisconsin has grown and developed so much that the greatest need now is more funds to meet the many calls for institutes which can not at present be satisfied. So far as Wisconsin is concerned, farmers' institutes have come to stay, and the only question now is how to keep them advancing so as to satisfy the demands upon them.

WYOMING.

The first active steps toward establishing farmers' institutes in Wyoming were taken at a meeting of the State industrial committee held at Sheridan, October 7–9, 1903.

At this meeting, in pursuance of some suggestions made before the committee in an address by the Farmers' Institute Specialist of the National Department of Agriculture, steps were taken by representatives of the State agricultural and mechanical college, and of the State agricultural experiment station to organize the institute work and endeavor to secure an appropriation from the State in its behalf.

The State agricultural college and the experiment station had been planning for the organization of this work for some years and had held at the college the previous year a meeting to which the farmers of the State had been invited. The difficulties due to the sparsely settled condition of the country districts and the lack of railroad communication made it impracticable for the members of the college faculty and the experiment station staff to visit the rural communities without additional aid from some source outside of the college and station funds to meet the expense.

To provide for this, Director B. C. Buffum, of the State experiment station prepared a bill which was presented before the eighth general assembly of the State at its session of 1903–4, which was incorporated in the general appropriation bill and past.

The portion relating to farmers' institutes is section 47 of the general appropriation bill, and provides $2,000 for the purpose of holding farmers' institutes and short courses in stock judging, agronomy, and general farming, the meetings to be arranged at such places and at such times as will accommodate the people of the community in which the meetings may be desired. The institutes or short courses are placed in charge of the agricultural department of the university which arranges the necessary details of the meetings. The board of trustees of the university is given authority to employ instructors and lecturers, to provide equipment, and to meet any necessary expenses incident to the meetings.

The first community to avail itself of the provisions of this act was Cody, Bighorn County, where Director Buffum conducted a three-day institute on March 29, 30, and 31, 1905. This was the first State institute held in Wyoming and will be followed by others at the close of the farming season.

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LIST OF PUBLICATIONS OF THE OFFICE OF EXPERIMENT STATIONS ON FARMERS' INSTITUTES.

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